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Mining and Metallurgical Section.

The Petroleums of North America. A Comparison of the Character of Those of the Older and Newer Fields.*

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(*Concluded from vol. clxii, page 70*)

OHIO-INDIANA FIELD.

Before 1885 the main supply of petroleum on the continent of North America was derived from the Appalachian field, the oil bearing strata not being of greater antiquity from a geological point of view than the lower Devonian. In that year a new field was developed in the North-western part of Ohio, the oil occurring in Trenton limestone of lower Silurian age. This, although a paraffine petroleum, differs essentially from the paraffine petroleum of the Appalachian field in that it is denser, contains a larger amount of sulphur, including hydro-

*Read by title.

gen sulphide, which gives it a very bad odor, and yields a much smaller amount of distillate suitable for illuminating purposes.

According to Mabery* the density of the petroleum from the Findlay and Lima fields varies, in the former case from .8194 to .8296, 40.8°B., to 38.8°B, and in the latter from .8243 to .8510; 39.8° to 34.5°B. The ultimate composition of the oil shows a smaller percentage of carbon, 84.57%, as might be expected. The percentage of distillates which he obtained from the crude petroleums of Pennsylvania and North-western Ohio, with their densities, compare as follows:

	Pennsylvania.			Ohio-Indiana.	
Fraction.	Parts in 100.	Sp Gr.	Fraction.	Parts in 100.	Sp. Gr.
120-150°	19.70		100-150°	9.75	.7282
150-200	8.84	.757	150-200	16.63	.7669
200-250	15.23	.788	220-257	10.75	.7940
250-320	20.70	.809	257-300	9.75	.8138
			300-350	8.63	.8242
Total	64.47			55.51	
Residue	35.52			43.00	

It will be noted that the distillates coming over below the boiling point of nonane, 151°, amount to twenty per cent. of the Pennsylvania and only ten per cent. in the Ohio oil, and that all the distillates from the latter are denser than those from the Pennsylvania oil.

Mabery† has made an elaborate study of this petroleum and has detected the paraffine hydrocarbons, C_nH_{2n+2} from butane, C_4H_{10}, boiling at 0°, up to and including a decane, $C_{10}H_{22}$, boiling at 173°, and corresponding to those found in the Pennsylvania petroleum. Above this the liquid members of this series fail. The solid paraffines occur, however, in a greater proportion than in the Pennsylvania oil, as they are present and separate out on cooling from all distillates above 150° at 30 mm. pressure. These solid paraffines have been assumed by Mabery, and probably correctly, to be identical with those found in the Pennsylvania oil. Above $C_{11}H_{24}$ satur-

*Am. Chem. Jour., 1895, *17*, 725.
†Am. Chem. Jour., 1895, *17*, 725.
Proc. Am. Acad, A. & Sci., 1904, *40*, 323.

ated hydrocarbons are found which on separation from the solid paraffines by freezing, correspond to the general formula C_nH_{2n}, with 12, 13, 14, 15, 16 and 17 atoms of carbon, having the following boiling points, specific gravities, and index of refraction:

HYDROCARBONS SEPARATED FROM OHIO TRENTON LIMESTONE PETROLEUM.

Series.	Symbol.	Boiling Point.	Pressure.	Specific Gravity.	Refractive Index.
C_nH_{2n}	C_{12} H_{24}	211-213°	At. pressure.	.7970	1.4350
"	C_{13} H_{26}	223-225	"	.8055	1.4400
"	C_{11} H_{23}	138-140	30 mm.	.8129	1.4437
"	C_{12} H_{26}	152-154	"	.8204	1.4800
"	C_{14} H_{28}	164-168°	"	.8254	1.4514
"	C_{17} H_{34}	177-179	"	.8335	1.4545

When the carbon atoms reach 19 in number and up to and including hydrocarbons having 21, 22 and 24 atoms, the relation of carbon to hydrogen corresponds to the general formula C_nH_{2n-2}.

Series.	Symbol.	Boiling Point.	Pressure.	Specific Gravity.	Refractive Index
C_nH_{2n-2}	C_{19} H_{36}	199-202°	30 mm.	.8364	1.4614
"	C_{21} H_{40}	213-217	"	.8417	1.4650
"	C_{22} H_{24}	224-227	"	.8614	1.4690
"	C_{24} H_{46}	237-240	"	.8639	1.4715

The hydrocarbons with 23, 24 and 25 atoms of carbon correspond to the general formula C_nH_{2n-4}.

Series.	Symbol.	Boiling Point.	Pressure.	Specific Gravity.	Refractive Index
C_nH_{2n-4}	C_{23} H_{42}	253-255°	30 mm.	.8842	1.4797
"	C_{24} H_{44}	263-265	"	.8864	1.4802
"	C_{25} H_{46}	275-278	"	.8912	1.4810

It appears from the preceding data that the saturated C_nH_{2n} hydrocarbons of higher boiling point begin at a much lower number of carbon atoms than in the case of the Pennsylvania oil. The same can be said of the saturated hydrocarbons C_nH_{2n-2}, while hydrocarbons of the series C_nH_{2n-4} are present which are not found in the Eastern oil. They correspond physically and chemically with those found in the asphaltic petroleums from Texas and California and in the lighter distillates from the solid bitumens, such as Trinidad

asphalt, as may be seen from a comparison of the characteristics of the three latter materials, of about the same boiling point, with the C_nH_{2n-4} hydrocarbons of Ohio oil.

	Trinidad Asphalt Distillate.	California Distillate.	Beaumont, Texas, Distillate.
Boiling Point	300-310°	265-270°	293-317°
Specific gravity	.8914	.8860	.8879
Refractive Index	1.4815	1.4860	1.4830
Carbon	85.98 %	86.59 %	85.95 %
Hydrogen	13.62%	13.32 %	13.48%

Mabery* has also found a much larger percentage of aromatic hydrocarbons in Ohio oil and mentions the occurrence of benzol, toluol and mesitylene boiling at 168°, and the higher homologues, including cumol, psuedocumol, durol, isodurol, cymol, isocymol, and doubtless others of even higher molecular weight.

The napthenes or monocylic polymethylenes are also found in Ohio oil to a very considerable extent, but have not been separated in detail.

With these data alone it is evident that Pennsylvania and Ohio oils are of quite different character, aside from the presence of the larger amount of sulphur derivatives in the Ohio oil and of asphaltic hydrocarbons containing 23, 24 and 25 atoms of carbon.

The sulphur compounds have not been isolated but are probably of the same nature as those occurring in Canadian petroleum.

In the same way, as in the case of the Pennsylvania petroleum, the residue from the distillation of oil from the Ohio field has been examined by the writer with the following results:

PHYSICAL PROPERTIES.

Specific gravity, 25/25°	.9318
Flash	224°

CHEMICAL CHARACTERISTICS.

Loss, 160°, 7 hours	3 %
Character of residue	Soft.

*Proc. Am. Phil. Soc., 1897, *36*, 154.

Loss, 200°, 7 hours (fresh sample)	7.4 %
Character of residue	Soft.
Bitumen soluble in CS_2, air temperature	99.4 %
Organic matter insoluble	.6
Inorganic or mineral matter	.0
	100.0
Bitumen insoluble in 88° B. naphtha, air temperature—pitch	3.8 %
Per cent. of soluble bitumen removed by H_2SO_4	17.0
Per cent. of total bitumen as saturated hydrocarbons	83.0
Per cent solid paraffines	11.4 %
Fixed carbon	3.7 %

From the preceding results it appears that there is no such striking difference between the two residues, as might be expected from the difference in the character of the oil in which they have originated. That from the Ohio oil contains about the same amount of unsaturated hydrocarbons removed by acid; and of paraffine scale, while it yields one per cent. more of fixed carbon. The density, as might be expected, is somewhat higher.

From the preceding data it is evident that the oil of the North-western Ohio field may be classed as a paraffine petroleum, but that it differs essentially from that of Pennsylvania in the nature of the liquid hydrocarbons of which it is made up, especially in the presence of asphalt hydrocarbons. It also contains larger amounts of napthenes, or monocylic polymethylenes, of aromatic hydrocarbons, of unsaturated hydrocarbons and of sulphur derivatives.

CANADIAN FIELD.

Petroleum occurs in the Province of Ontario, Dominion of Canada, in the corniferous limestone, of a character somewhat resembling that from the Ohio-Indiana field, as it contains sulphur, although in a rather larger amount, one per cent., as compared to six-tenths of one per cent. It has a very considerably higher density, .84 to .88, 36.7° to 29.1°B. It has been

closely studied by Mabery* who finds that in ultimate composition it compares with Ohio oil as follows:

	Canadian.	Ohio.
Carbon	83.94 %	84.57 %
Hydrogen	13.37	13.62
Sulphur	.99	.60
	98.30	98.79

The comparative yield of distillate from the two oils is presented by Mabery as follows:

Boiling Point.	Per cent.	Specific Gravity.
	CANADA. (Petrolia..)	
100-150°	2.75	.7670
150-200	7.80	.8026
200-250	9.50	.8228
250-300	5.10	.8345
300-350	3.10	.9037
Total	28.25	
Residue	70.12	
	OHIO.	
110-150°	9.75	.7282
150-220	16.63	.7669
220-257	10.75	.7940
257-300	9.75	.8138
300-350	8.63	.8242
Total	55.51	
Residue	43.00	
	PENNSYLVANIA.	
120-150°	19.70	
150-200	8.85	.757
200-255	15.23	.788
255-320	20.70	.809
Total	64.48	
Residue	35.52	

*Am. Chem. Jour., 1896, *18*, 53, and 1897, *19*, 419.
Proc. Am. Phil. Soc., 1903, *42*, 36.
Proc. Am. Acad. A. and Sci., 1904, *40*, 334, and 1905, *41*, 89.

From the preceding figures it is very evident that the Canadian petroleum contains a very much smaller percentage of hydrocarbons distilling at comparatively low temperatures, than either the Ohio or Pennsylvania oil.

In the Canadian, as in the Ohio oil, the liquid members of the series C_nH_{2n+2} stop with $C_{10}H_{22}$, but the proportion of these present is, of course, much smaller. Above this point the liquid hydrocarbons are poorer in hydrogen, and include the C_nH_{2n-2} and C_nH_{2n-4} series, of which the following were separated:

	Boiling Point.	Pressure.	Sp. Gr. 20°	Refractive Index.
C_{12} H_{24}	216°	760 mm.	.....	.....
C_{13} H_{26}	228-230	760 mm.	.7979	1.444
C_{14} H_{28}	141-153	50 mm.	.8096	1.449
C_{15} H_{30}	159-169	50 mm.	.8192	1.452

The aromatic hydrocarbons have been shown to be present in greater amount than in Pennsylvania or even Ohio oil. The sulphur compounds, owing to the larger percentage of sulphur present, are of much importance in affecting the character of the oil. Mabery* has isolated those containing from seven to eighteen atoms of carbon, corresponding to the general formula $C_nH_{2n}S$, having the following characteristics:

	Boiling Point.	Sp. Gr. 20°	Refractive Index.	Pressure.	Sulphur.
C_7 H_{14} S	158-160°	.8878	1.468	760 mm	24.61 %
C_8 H_{12} S	167-169	.8929	1.486	"	22.22
C_8 H_{16} S	183-185	.8937	.....	"	22.22
C_9 H_{18} S	193-195	.8997	1.4746	"	20.25
C_{10} H_{20} S	207-209	.9074	1.4766	"	18.60
C_{11} H_{22} S	128-130	.9147	1.480	50 mm	17.20
C_{14} H_{28} S	160-170	.9208	1.4892	"	14.04
C_{16} H_{32} S	170-180	.9222	1.4903	"	12.50
C_{18} H_{36} S	190-210	.9235		"	11.27

Mabery† has identified a number of the unsaturated hydrocarbons of the C_nH_{2n} series, obtained from sludge produced in the purification of the saturated hydrocarbons, as hexylene, heptylene and nonylene, the presence of which is of interest

*Proc. Am. Acad. A. and Sci., 1905, *41*, 89.

† Proc. Am. Aacd. A and Sci., 1905, *41*, 107.

and which may possibly occur in smaller amounts in Pennsylvania and Ohio petroleum.

The napthenes or monocyclic polymethylenes do not seem to have been isolated from Canadian oil, probably owing to the small percentage of light distillates which the petroleum contains.

The residues from these distillates have been found by the writer to be very rich in scale paraffine, as shown by the following results:

PHYSICAL PROPERTIES.

Specific Gravity, 25/25°	.9355
Flash	233°

CHEMICAL CHARACTERISTICS.

Loss, 160°, 7 hours	.2 %
Character of residue	Soft.
Loss, 200°, 7 hours	7.8 %
Character of residue	Soft.
Bitumen soluble in 88°B naphtha, air temperature—Pitch	4.7 %
Per cent. of soluble bitumen removed by H_2SO_4	10.0
Per cent. of solid paraffines	19.0 %

That such a large percentage of solid paraffine adds to the stability of this residue is seen by the fact that but 10% is removed on treating it with naptha solution with strong sulphuric acid. The showing in this respect is in contrast to that of the residues from the Pennsylvania and Ohio oils, where the amount removed may reach 20%.

From the preceding data it appears that the Canadian oil, like that from Pennsylvania and North-western Ohio, may be classed as a paraffine petroleum, since it contains a predominating amount of hydrocarbons of the C_nH_{2n+2} series, especially in the solid form. It differs from these petroleums in that the amount of distillate below 150° is very much smaller, while the sulphur derivatives of the polymethylenes are present in very much larger amount, as are the aromatic and unsaturated hydrocarbons in the lower distillates, while the higher residues contain larger percentages of the solid paraffines and less unsaturated hydrocarbons. It resembles Ohio oil in having the lower liquid asphaltic hydrocarbons as components.

COLORADO FIELD.

Petroleum is found in several localities in Colorado, but the source of the principal industrial supply is in the Florence oil field. It is situated in Fremont County, in the valley of the Arkansas river, in close proximity to the eastern base of the Rocky Mountains.* The oil, a paraffine one, is contained in strata which are considered to belong to the Fort Pierce group of the Montana Cretaceous.† The crude petroleum is of a dark green color, of not unpleasant odor and has an average gravity of .8696, 31.0°B. It contains but a very small percentage of naphtha and yields from 35 to 40% of illuminating oils.

The hydrocarbons composing this distillate are largely of the C_nH_{2n+2} series, but the individual members have not been isolated nor is it known at what point hydrocarbons in which the percentage of hydrogen to carbon is smaller, begins.

The residuum is rich in paraffine. An examination by the writer resulted as follows:

PHYSICAL PROPERTIES.

Specific gravity, 25/25°	.9268
Flash	221°

CHEMICAL CHARACTERISTICS.

Loss, 200°, 7 hours	2.4 %
Character of residue	Soft.
Bitumen insoluble in 88° naphtha, air temperature—Pitch	.1 %
Per cent. of soluble bitumen removed by H_2SO_4	19.0
Per cent. of solid paraffines	10.4
Fixed carbon	1.6 %

It will be seen that this residuum is quite similar to that from the Eastern paraffine oils in all respects.

Petroleum is also found near Boulder, Boulder County,‡ which in its crude state has a very low gravity, .8116, 42.5°B., corresponding to that of Pennsylvania oil. This oil, however,

*Geo. H. Eldridge, Trans. Am. Inst. Min. Eng., 1891.

†U. S. Census, Mines and Quarries, 1902, 739.

‡Contributions to Economic Geology, U. S. Geol. Survey, 1902, 322.

has not yet reached a position of great industrial importance. Unlike the Florence oil it carries 17% of naphtha.

Wells have been drilled in thirteen other counties in the State, but no supply of importance has been developed.

WYOMING FIELD.

Petroleum occurs, rather widely distributed, over the State of Wyoming. Industrially, the amount produced is of small importance, being only 11,542 barrels in 1904, and coming from the Salt Creek oil field in Johnson and Natrona Counties, about fifty miles north of Casper, on the North Platte River.

The oils are rather heavy, having a density of .91, 23.9°B. It is found in the sands in the horizon below the Fox Hill group of the Cretaceous, although some may be found in the Tertiary and in strata as old as the Carboniferous.*

The petroleum of Wyoming has not been examined with any degree of thoroughness, but sufficiently to show that it leaves an asphaltic residual pitch on distillation, although paraffine scale has been observed in some distillates. It is a dark green oil of reddish-brown color by transmitted light.

According to the late Professor W. C. Knight, of the University of Wyoming, on distillation with superheated steam distillates were obtained having a specific gravity as high as .97, 14.3°B., and over, while little or none was obtained lighter than .860, 32.8°B.

In other parts of the State, oils have been examined by Knight, having the same density and character as that from the Salt Creek field, but containing noticeable percentages of sulphur, .10 to .30, while in the so-called Bonanza field an oil of .845 gravity, 35.7°B., occurs, carrying but .015% of sulphur and containing 10% of distillate below 150°.

A petroleum having a gravity of .916, 22.8°B., obtained in the vicinity of Newcastle, Weston County, separates, according to Knight, paraffine scale.

From other parts of the State petroleum having a density as high as .98, 12.9°B., is found, and it appears, therefore, that the character of the petroleum of Wyoming is most varied,

*W. C. Knight, Bulletin No. 1, The School of Mines, University of Wyoming, 1896, p. 16.

ranging from a comparatively light oil of density .81, 42.8°B., to the heavy asphaltic oils of density .98, 12.9°B.

CALIFORNIA FIELD.

Petroleum is found in California principally to the south of the latitude of San Francisco, although prospects occur to the north of this which are at present of smaller industrial importance. The fields lie on either side of the Coast Range, those originally developed being along the sea coast in Santa Barbara, Ventura, Los Angeles and Orange Counties, while the largest fields are in the Central Valley of the State, to the east of the range in Fresno and Kern Counties, these two producing by far the largest amount of any in the State, although the latter has been developed only within the last six or seven years. Oil is also produced on a smaller scale in San Mateo and Santa Clara Counties.*

The oil-bearing strata are of from Eocene to Pliocene age, which are reached in wells at depths of from 300 to 3,000 feet.

The production of petroleum in California is the largest in amount of that in any State of the Union, although as a field that of the Appalachian is greater. It has increased sevenfold since 1900. Owing to its inferior character for the production of illuminating oil, the output is only fifth in value.

The density of California petroleum varies from .8235, 40.0° B., for some from Colusa County, .8485, 35.0°B., for that found in Santa Clara County, and from Fresno County, to .9859, 12.0°B, in Santa Barbara County. In color the oil varies from yellow to almost black.

As can be seen from its varying density, California petroleum is quite varied in character. The densest oil is found in the Summerland field in Santa Barbara County, in Los Angeles County, and in the Sunset field in Kern County. The characteristics of the oils can conveniently be taken up by counties or fields.

Santa Barbara County—Summerland Field: A specimen of

*For further information as to the occurrence of petroleum in California, see the Petroleum Fields of California, Eldridge, Contributions to Economic Geology, 1902, U. S. Geol. Survey, Washington, Government Printing Office, 1903.

the dense Summerland oil collected by the writer and distilled in vacuo at a pressure of 26 mm., gave 55% of distillate which was collected in fifteen fractions, having the following specific gravity at 20°.

Fraction.	Sp. Gr.
1	.8712
2	.8833
3	.8893
4	.9034
5	.9155
6	.9336
7	.9417
8	.9477
9	.9618
10	.9678
11	.9738
12	.9802
13	.9830
14	.9900
15	.9939 Ref. Index 1.542
Residue, 45 per cent. A hard asphalt.	Penetration 66.

The highest boiling fraction has a density very nearly that of water and a refractive index of 1.542. The residue consisted of a hard residual pitch. On redistilling the first fraction at the same pressure, distillates began to come over at 105°, having a specific gravity of .8460, 35.5°B., and a refractive index of 1.460. Paraffine scale could not be separated from any of the fractions on exposing them to an extremely low temperature.

Mabery* has examined this oil in considerable retail. He found that a sample which he obtained, having a specific gravity of .9845, 12.2°B., had the following ultimate composition:

Carbon	86.32 %
Hydrogen	11.70
Nitrogen	1.25
Sulphur	.84
	100.11

His distillates were of a character similar to those found by the writer. He continued his fractionation until heaps were

*Proc. Am. Acad. A. and Sci., 1904, *40*, 340.

obtained at certain temperatures. After purification with sulphuric acid and caustic soda, he examined the saturated hydrocarbons thus obtained with the following results:

HYDROCARBONS SEPARATED FROM SANTA BARBARA (CAL.) PETROLEUM.

Symbol.	Boiling Point.		Sp. Cr. at 20°	Ref. Index.
$C_{13}H_{24}$	150-155°	60 mm.	.8621	1.4687
$C_{15}H_{30}$	175-180	"	.8808	1.4700
$C_{17}H_{30}$	190-195	"	.8919	1.4778
$C_{18}H_{32}$	210-215	"	.8996	1.4814
$C_{20}H_{44}$	250-255	"	.9299	
$C_{27}H_{46}$	310-315	"	.9451	1.5146
$C_{30}H_{50}$	340-345	"	.9778	

The most volatile of these fractions belong to the C_nH_{2n-2} series. With the third the series becomes C_nH_{2n-4}, and with the sixth C_nH_{2n-8}, the density of the last fraction and its boiling point being extremely high. A hydrocarbon of the C_nH_{2n-2} series of very similar molecular weight, has also been separated by the writer from Trinidad asphalt and found to have the following physical characteristics:

Boiling Point	147-170° at 30 mm.
Specific gravity	.8576
Beaumé	33.20
Refractive Index	1.465
Carbon	86.85%
Hydrogen	13.34

The resemblance between the physical properties and ultimate composition of these fractions with some of those obtained by Mabery, renders it probable that the same series are present in Trinidad asphalt as in California oil. The latter oil is, without doubt, extremely asphaltic in nature, as is evident from the fact that it leaves 45% of hard pitch, resembling asphalt, on distillation in vacuo.

On distillation with steam of the sludge obtained from treating the above distillates with strong sulphuric acid, the sulphur derivatives of the petroleum, the presence of which is shown by the ultimate analysis, have been recovered by the writer and found to correspond to those obtained in Canadian oil.

On treatment of the distillates with dilute sulphuric acid, one to four, the nitrogen derivatives, the presence of which is also

shown by the ultimate analysis, can be recovered. They are probably hydroquinolenes. Their examination has been undertaken by Mabery.* He finds that fractions of the nitrogenous oil, separated by repeated distillation, have the following composition:

130-340°	$C_{12}H_{17}N$
197-199	$C_{13}H_{15}N$
215-217	$C_{14}H_{19}N$
223-225	$C_{15}H_{19}N$
243-245	$C_{16}H_{19}N$
270-275	$C_{17}H_{21}N$

Santa Barbara County—La Graciosa District: In the interior of Santa Barbara County, near Santa Maria, in the Graciosa Hills, petroleum has been produced in large amounts very recently from wells which were opened up towards the close of the year 1903, on the Careaga Ranch. This oil† has a specific gravity of about .85, 34.7°B., and yields about 36% of distillate below 200°. It is much lighter than that from the Summerland field, and consequently of much greater value. It has not yet been examined in any detail.

Los Angeles and Orange Counties: The oil produced in Los Angeles County is of two kinds. That in the district including and immediately adjoining the city of Los Angeles being a heavy oil, of an average density, .9790, 13.0°B., with extremes of .9859 and .9396, 12.0 and 19.0°B., and largely associated with water. In two other districts, one adjoining the oil fields of Orange County and the other those of Ventura County, lighter petroleums are found. The former produced petroleum having a density of .9655, 15.0°B., to.9211, 22.0°B., while the latter, in Pico Canyon, furnishes one of the lightest oils found in the State, having a density of about .84, 36.7°B., yielding, according to Cooper‡ the following distillates:

Under 100°	10.5 %
100-150	20.4
150-200	13.8
200-250	13.0

*J. Soc. Chem. Ind., 1900, *19*, 505.

†H. N. Cooper, Chemist of the California State Mining Bureau, Bulletin 31.

‡loc. cit.

250-300	11.1
Residue	31.2
	100.0

Solid hydrocarbons are separated from some of the distillates of this oil on cooling, and it has been stated that these are paraffines and that at one time they were extracted on an industrial scale. These solid hydrocarbons have not yet, however, been identified as paraffines by any acceptable authority. Solid hydrocarbons which are not paraffines have been separated from some of the oils from Ventura County, as will appear later,

A distillation of the petroleum from the Eastern Los Angeles County field, which was carried out by the writer, resulted as follows:

Fraction 26 mm.	Per cent. Distillation.	Sp. Gr. 20/20°	Refractive Index.	Color.
136-178°	3.7	.8654	1.474	Light red.
178-198	3.8	.8760	1.480	Deeper.
198-205	3.8	.8865	1.486	"
205-232	3.7	.8986	1.495	"
232-235	3.8	.9101	1.502	"
235-240	3.8	.9196	1.509	"
240-254	4.0	.9314	1.517	"
254-265	4.1	.9420	1.523	"
265-289	4.0	.9502	1.530	"
289-293	4.0	.9743	1.533	"
293-298	4.8	.9796	1.536	"
Residue	59.0			Reddish - black, very viscous but flows slowly.

LOSS BY TREATMENT WITH DIFFERENT REGENTS.

Fraction.	Sodium Hydrate NaOH	2-1 Sulph. Acid H_2SO_4	Conc. Sulphuric Acid.
130-178°	1.6%	1.2%	3.3%
178-198	.8	2.1	6.3
198-205	1.5	2.3	6.8

The oil resembles that from the Summerland field and leaves on distillation a large percentage of asphaltic residue. Treatment of the lower distillates with sodium hydrate and acid removes but a comparatively small per cent. of nitrogenous

bases, sulphur derivatives and unsaturated hydrocarbons. When two hundred c.c. is distilled from an Engler distilling flask, the following percentages of distillate are obtained:

Under 200°	0.0%
200-250	4.0
250-300	13.9

Cracking begins at temperatures much above 300°, and strong smelling distillates, amounting to 50%, may be obtained, leaving a residue of 30 to 40% of pitch, according to the care with which and the extent to which the distillation has been carried out. That a much larger percentage of pitch than this is obtained, was found to be the case by the writer, if the oil is allowed to evaporate in an open dish at from 12 to 24 hours, at a temperature of 200°, when as much as 60% will be obtained. In the actual distillation of such oils in the refineries the temperatures are often carried to 400°, or even higher, both distillates and residual pitch being much decomposed. The residual oils and pitches obtained in this way, when the greatest care is exercised in distillation, have the following composition:

CALIFORNIA RESIDUAL OIL.

("G" Grade.)

PHYSICAL PROPERTIES.

Specific gravity, 25/25°	1.006
Flashes	191°

CHEMICAL CHARACTERISTICS.

Loss 160°, 7 hours	3.2 %
Character of residue	Soft.
Loss 200°, 7 hours (fresh sample)	17.3 %
Character of residue	Soft.
Bitumen soluble in CS_2, air temperature	99.7 %
Organic matter insoluble	.3
Inorganic or mineral matter	.0
	100.0
Bitumen insoluble in 88°B. naphtha, air temperature—Pitch	7.7 %
Per cent. of soluble bitumen removed by H_2SO_4	54.9
Per cent. of total bitumen as saturated hydrocarbons	41.9

Per cent. of solid paraffines..... 0.0 %

Fixed carbon ..... 6.0 %

CALIFORNIA RESIDUAL PITCH.

("D" Grade.)

PHYSICAL PROPERTIES.

Specific gravity, 25/25°.....	1.062
Color of powder or streak.....	Black
Lustre	Lustrous
Structure	Uniform
Fracture	Tacky
Hardness, original substance.....	Sticky
Odor	Asphaltic
Softens	61°
Flows	69°
Penetration at 25°.....	52

CHEMICAL CHARACTERISTICS.

Loss 160° 7 hours.....	.83 %
Character of residue.....	Hard.
Loss 200°, 7 hours (fresh sample).....	6.2 %
Character of residue.....	Hard.
Bitumen soluble in CS_2, air temperature.....	99.3 %
Organic matter insoluble.....	.4
Inorganic or mineral matter.....	.3
	100.0

MALTHENES:

Bitumen soluble in 88° B. naphtha, air temperature.....	77.0 %
This is per cent. of total bitumen.....	77.5
Per cent. of coluble bitumen removed by H_2SO_4.....	47.8
Per cent. of total bitumen as saturated hydrocarbons.....	40.5
Bitumen soluble in 62° B. naphtha.....	82.2 %
This is per cent. of total bitumen.....	80.0

CARBENES:

Per cent. of bitumen insoluble in carbon tetrachloride, air temp...	.5 %
Fixed carbon	15.0 %

Residues like the above are known as California flux and California asphalt, and have been used more or less satisfactorily in the construction of asphalt pavement. They are free from paraffine scale and are distinguished from similar residues

from paraffine petroleum by yielding a much higher percentage of fixed carbon, the amount being proportionate to the hardness of the material.

Los Angeles County: Petroleum from the Southern part of Los Angeles County, in the Puente Hills, and the adjoining fields in Orange County is quite variable in character. Some of it has a density as high as .8537, 34.0° B., in the Olinda fields, while other oil from the same field has a density of .9396, 19.0° B. The lighter oil affords the following percentages of distillates, according to Cooper:

Under 100°	12.9 %
100-150	15.3
150-200	11.5
200-250	11.1
250-300	9.6
Residue	39.6
	100.0

One of the denser oils has been examined by the writer with the following results:*

OIL FROM THE FULLERTON OIL WELLS OF THE A., T. & S. F. R. R.

Color	Brown
Specific gravity, 20/20°	.9393
Beaumé	19.5°
Loss 200°, 7 hours	42.7
Character of residue	Soft, maltha, sticky, and drawing to a long thread.
Flash	26°

Boiling Point.	Color of Distillate	Per cent. Distillated.	Sp. Gr. 25/25°	Refractive Index.
Atmos. Pressure:				
35-135°	Colorless.	2.4	.7880	1.423
135-175°	Pink.	8.2	.8319	1.435
25 mm. Pressure:				
40-100°	Green.	4.2	.8745	1.455
100-150°	Dark red.	10.4	.9195	1.478
150-165°	Dark red.	7.0	.9547	1.496
Begins to crack,				
Residue	.....	66.4	.....	.....
Loss, gas.	.....	1.4	.....	.....
		100.0		

*J. Soc. Chem. Ind., 1900, *19*, 123.

The preceding distillates when treated with sodium hydrate solution and sulphuric acid lost the following percentages of phenols and bases:

Boiling Point.	Per Cent. Distillate.	Loss with ten Per cent. soda.	Loss with concentrated acid.
Atmos. Pressure:			
35-135°	2.4	0.0	0.7
135-175	8.2	1.2	1.3
25 mm. Pressure:			
40-100°	4.2	2.3	4.7
100-150	10.4	2.9	4.9
150-165	7.0	6.8	13.3
Residue	66.4	8.7	33.3

Density of Distillates before and after Treatment.

Boiling Point.	Density		Refractive Index.	
	Before.	After.	Before.	After.
Atmos. Pressure:				
35-135°	.7880	.7338	1.423	1.430
135-150	.8319	.7798	1.435	1.437
25 mm. Pressure:				
40-100°	.8745	.8169	1.455	1.454
100-150	.9195	.8593	1.478	1.477
150-165	.9547	.8774	1.496	1.494
Residue	.....	.8975	.....	.....

Both of these substances can be recovered, the phenols at times in crystalline condition. The bases are the same as those found in other California oils, while they are accompanied by some aromatic hydrocarbons and sulphur derivatives, the oil carrying .28% of sulphur.

Ventura County: Ventura County is the location from which the earliest supplies of California petroleum were obtained as long ago as the sixties. The fields are scattered through its Southern part, on both sides of the Santa Clara Valley and in the neighborhood of Santa Paula.* The oils are of the most varied character, ranging from a very dense one carrying a large percentage of nitrogen and sulphur, in the Ojai district, to the lighter oil of the Bardsdale and Torrey fields, from the distillates of which solid hydrocarbons separate at ordinary temperatures. These oils have been examined by the writer with the following results:

*Mineral Resources, U. S. Geol. Survey, Eldridge, 1902.

OIL FROM OJAI VALLEY.

Fraction.	% Distilled.	Loss with NaOH	Loss with H_2SO_4	Specific Gravity Before treatment.	Specific Gravity After treatment.	Refractive Index Before treatment.	Refractive Index After treatment.
Original oil:				.9175			
30- 80°	7.8	2.1	3.3	.7680	.7826	1.435	1.437
80-118	7.8	3.3	4.4	.7728	.8200	1.455	1.455
118-150	7.8	4.0	8.5	.8334	.8583	1.478	1.476
150-181	8.0	11.1	9.0	.8750	.8907	1.498	1.495
181-213	8.0	12.7	10.5	.8939	.9079	1.512	1.506
213-248	8.0	13.9	12.7	.9292	.9257	1.526	1.516
248-274	7.8	2.1	16.3	.9605	.9394	1.537	1.517
Residue.	43.8	....	....	1.0100	.....	.....	.....
Loss	1.0	....	....	.....	.....	.....	.....

This oil is marked by the fact that 11, 12 and 14% of the distillates boiling between 150 and 250°, at 26mm., consist of phenoloid bodies removed by treatment with sodium hydrate, while an almost equal amount of nitrogenous bases are removed by sulphuric acid. The change in the specific gravity of the distillates after treatment is striking, the result being an increase in some and decrease in others.

BARDSDALE OIL.

Before Treatment.

Fraction	% Distilled	Color	Sp. Gr. 20°	Refractive Index
Original		Deep brown-black	.8869 (29°B.)	
60-120°	10.0	Colorless	.7316	1.414
120-154	12.0	"	.7481	1.419
26 mm. Pres:				
48-116°	13.0	Light yellow	.7972	1.443
116-152	12.0	Light green	.8420	1.469
152-198	11.0	Darker green	.8724	1.486
198-255*	10.0	Yellow brown	.9035 (at 25°)	1.501
255-310**	6.0	Reddish brown	.9216 (at 45°)	1.521
Residue	25.4	Penetration about 60		

* Little paraffine. ** Solid with paraffine.

After Treatment.

Fraction	Color	Loss with NaOH	Loss with H_2SO_4	Sp.Gr.	Refractive Index
62-120°	Colorless	1.1%	1.7%	.7387	1.420
120-154	"	1.4	3.8	.7493	1.420
26 mm. Pres:					
48-116°	"	1.0	5.3	.7932	1.441
116-152	"	.9	9.0	.8330	1.463

152-198	Light Yellow	1.9	16.3(a)	.8572	1.478
198-255	" "	1.6	18.7(b)	.8900	1.498
255-310	Reddish Brown	1.3	34.7	9.001	1.510

(a) Melts at 25°. (b) Melts at 43°.

The preceding distillates, obtained at a pressure of 26mm., with the exception of the two lower fractions, have a very much lower density than those of the denser California petroleums. The distillates at atmospheric pressure below 150° amount to 22%. The fractions above 200°, at 26mm., all separate solid hydrocarbons which have not been closely identified. Mabery has examined a similar oil from the adjoining Torrey Canyon field and isolated from the distillates solid hydrocarbons in crystals that melt at 57° to 62°, and which are not paraffines. He also found* that this carried quite an amount of sulphur, .84%, and a very considerable percentage of nitrogen. The crude oil has the following composition:

Carbon.....85.60%
Hydrogen.....12.84

In the lower distillates benzol and toluol were present in marked amount and the density of these distillates was much higher than would make it possible for the occurrence of C^nH_{2n+2} hydrocarbons, and it seems, therefore, from Mabery's examination that none of these exist and that the lower boiling components of this oil are aromatic and napthene hydrocarbons.

The writer has also examined a specimen of the Torrey Canyon oil with the following results:

TORREY CANYON OIL.
Before Treatment.

Fraction	% Distilled	Color	Sp.Gr. 20°	Refractive Index
Original oil		Dark reddish-brown	.8650	
Atmos. Pres:				
47-116°	6.0	Colorless	.7200	1.412
116-145°	12.4	"	.7523	1 428
26 mm. Pres:				
36-94°	12.7	Very light yellow	.7912	1.440
94-132	14.0	" " "	.8255	1 458
132-195 (a)	17.6	Yellow	.8520	1.475

*Am. Chem. Jour, 1897, *19*, 797.

195-242 (b)	15.0	Greenish	.8808	1.491
242-280 (c)	15.0	Dark yellow	.8981(40°)	1.504
280-310 (d)	6.2	Dark brown-reddish	.9156	1.523
	98.9			
Loss	1.1			

Residue, 24.6 %, is a hard asphalt with appearance of paraffine.

(a) Some solid hydrocarbons. (b) Considerable solid hydrocarbons.
(c) Solid hydrocarbons. (d) Solid hydrycarbons.

After Treatment.

Fractions	Color	Loss with NaOH	Loss with H_2SO_4	Sp Gr.	Ref. Index	Melts at
47-116°	Colorless	——	2.5%	.7232	1.418	——
116-145	"	——	2.8	.7542	1.424	——
26 mm. Pres :						
36-94°	"	——	5.1	.7903	1.441	——
94-132	"	0.5%	7.0	.8236	1.459	——
132-195	Light yellow	1.9	13.0	.8423	1.471	——
195-242	" "	2.2	15.2	.8528	1.482	——
242-280	Yellow	1.1	21.7	.8733	1.497	30°
280-310	"	1.4	24.2	.8878	1.504	36°

The gravity of the higher distillates in both the Bardsdale and Torrey Canyon oils is much less than in the usual asphaltic oils, and this, as has been said, is a very distinguishing character of these petroleums. For example, the distillates of the same boiling point in the Los Angeles, Torrey Canyon and Bardsdale oil compare as follows:

	Los Angeles.	Bardsdale.	Torrey Canyon.
Boiling point 30 mm.	293-296°	255-310°	280-310°
Specific gravity	.9796	.9216	.3878
Refractive Index	1.536	1.521	1.504

The Torrey Canyon oil carries a very considerably larger amount of solid hydrocarbons than the Bardsdale and the distillates are of much lower density and refractive index for the same boiling point. From a scientific point of view it is one of the most interesting petroleums of California and will eventually repay further and careful study.

The Torrey Canyon and Bardsdale oils differ most strikingly from that from the Ojai Valley by their lesser density, the presence of solid hydrocarbons and the absence of any considerable amounts of phenoloid bodies removed by sodium hydrate.

The petroleum from other fields in Ventura County are var-

ied in character but possess no such extreme characteristics as those which have been described, resembling much more the oils from other parts of the State. Typical of these oils is the following from the Sespe district:

FOUR FORKS OIL.

Before Treatment.

Fractions	% Distillate	Color	Sp. Gr. 20°	Refractive Index
Original oil		Reddish brown	.8651 (32.5°B)	
48-115°	Equal vol.	Colorless	.7483	1.418
115-148	" "	"	.7066	1.412
26 mm. Pres:				
56-96°	" "	"	.7855	1.437
96-138	" "	Light green	.8200	1.454
138-173	" "	" "	.8470	1.469
173-219	" "	" "	.8730	1 484
219-265	" "	Bright yellow	.9026	1 502
265-284	" "	Reddish brown	.9214	1.513
Residue	21.2	Penetration 310	——	——

After Treatment.

Fractions	Color	Loss with NaOH	Loss with H_2SO_4	Sp.Gr.	Refractive Index
48-115°	Colorless	1.4%	.9%	.7512	1.424
115-148	"	1 5	1.1	.7102	1.412
26 mm. Pres:					
56-96°	"	.9	1.4	.7855	1.437
96-138	"	2.0	1.4	.8195	1 456
138-173	Light green yellow	3.1	4.6	.8435	1.469
173-219	" " "	4 6	6.8	Lost	——
219-265	Dark brown	4.6	5.3	.9151	1.499
265-284	" "	2.2	18.1	.9221	1.502

This is a light oil containing considerable distillate below 150° at ordinary atmospheric pressure. Above this point the distillation was carried on in a vacuum at 26 mm. and a residue of only 21%, having a consistency of thick flux, was left. None of the fractions showed any signs of solid hydrocarbons on freezing and they were not strongly acted upon by sodium hydrate or sulphuric acid. The second distillate under atmospheric pressure is remarkable for its specific gravity, this being very much lower than the lighter distillate which came off before it.

Like the Bardsdale and Torrey Canyon oil the specific gravity

of the heaviest distillate is much less desirable at the same temperature than that from Summerland, Los Angeles and other heavier oils, that is to say, it is not so asphaltic in its nature. These facts do not seem to have been brought out hitherto.

Central Valley of California: The most important oil fields of California are situated in the Central Valley to the east of the Coast Range, in the Counties of Kern and Fresno, which produced in 1904 respectively 19,608,045 and 5,114,958, or 24,723,003 barrels out of a total production in the State of 29,649,434 barrels.

Kern County: As a producer to any considerable extent Kern County first appears in 1900 with something less than a million barrels of oil, derived chiefly from the field on the Kern river, in the neighborhood of Bakersfield, although small amounts were produced in the Sunset and McKittrick fields.

The Kern river oil has a density of from .9859 to .9396, 12.0 to 19.0° B. It contains from .75 to 1.0% of sulphur and yields, according to Cooper,* the following percentages of distillates:

	19° B.		12° B.	
	Distillates.	Sp. Gr.	Distillates.	Sp. Gr.
Up to 100°	0.0	....	....	....
100-150	4.0	.779	....	....
150-200	8.4	.816	0.0	....
200-250	12.1	.864	2.4	.876
250-300	14.6	.898	25.0†	.899

†Cracking begins in this distillation.

This oil has not been examined as yet in greater detail.

An oil from a shallow well in the Sunset district, which lies on the western side of the valley, collected by the writer in 1898, had a density of .9784, 13.1° B. It was distilled in vacuo, 26mm., with the following results:

HEAVY OIL SUNSET DISTRICT—1897.

Distilled at pressure of 25 mm. after drying.

Fraction.	+ Distillate.	Specific Gravity.	Refractive Index.
60-100°	.9		
100-145	8.0	.8670	
145-190	8.0		

*loc. cit.

190-220	8.0	.9209	
220-244	8.0	.9347	1.523
245-270	8.0	.9621	1.526
Residue	59.1	(Penetration 95)	

Treated with a 10% solution NaOH and H_2SO_4.

Fraction.	Loss with NaOH	Loss with H_2SO_4	Conc. H_2SO_4	Specific Gravity.	Refractive Index.
60-100°	8.5 %				
100-150	4.7	1.5 %	3.5 %	.8656	
145-190	5.1	.5	6.0	.8888	
190-220	5.8	1.8	14.6		
220-244			26.4	.9408	1.524

The higher distillates were so viscous that they flowed but slowly at ordinary temperatures and the most so of any distillates observed by the writer from California petroleum. No solid hydrocarbons separated from these distillates in a freezing mixture.

The second and third distillates were redistilled in a vacuum of 26 mm. after treatment with alkali and acid and the distillates collected in fractions of 5°. They were all water white.

Fraction.	Amount Distilled.	Specific Gravity 20°	Refractive Index
100°	20 c.c.	.8281	1.453
125-130	40	.8607	1.471
140-145	100	.8778	1.482
155-160	75	.8943	1.493
175-180	75	.9083	1.502
200-205	75	.9276	1.515
220-225	75	.9356	1.520
240-245	60	.9457	1.525
260-265	30	.9532	1.529
275-280	20	.9560	1.529
290-295	15	.9579	1.533

The above results can be compared with some interest with the distillates from Summerland oil, and it would appear that the hydrocarbons in the two oils are practically identical, but do not agree in all respects with those isolated by Mabery.

Fresno County: The petroleums of Fresno County are very varied in character and have a density of from .9859 to .8000, 12.0 to 45.0°B., but averaging .8589, 33.0°B. Cooper has

found from .06 to .94% of sulphur in the oil, while Mabery* from his examination of oil found in this county, having a density of .8423, 36.2°B., at 20°, found but .21% of sulphur, together with carbon 86.24 and hydrogen 13.08%. On distillation under atmospheric pressure he obtained the following fractions, all of which were colorless below 250°.

	Distillates.	Sp. Gr.
150°	33.06 %	.7829
150-200	24.79	.8268
200-250	20.66	.8725
250-300	12.40	.9090
Residue	9.09	.9356

These light petroleums have not been very carefully studied, but it is evident that they differ essentially, as shown by the specific gravity of the distillates, from the heavier California oils, and probably contain very considerable percentages of the napthenes. No separation of paraffine scale or solid hydrocarbons from the distillates has been noted, but the lightest Fresno oils contain a certain percentage of asphalt, amounting to at least 5 to 10%.

From the preceding data it appears that the petroleums of California are of the most varied character and that all of them consist of more or less dense asphaltic hydrocarbons. Nitrogenous bases are often present in very large amounts and again in only small amounts. Phenols are a common constituent of the denser oils. Except in those constituents which boil at a comparatively low temperature the components of California oils are unique in their density and viscosity.

None of the components is of the paraffine series and the hydrocarbons being largely of the C_nH_{2n} and C_nH_{2n-2} series, among those of sufficient volatility to be used as illuminating oils the distillates below 150° do not make good burning oil. They burn with a smoky flame and must be mixed with a large proportion of Eastern kerosene before they can be used.

TEXAS FIELD,

The petroleums of Texas are somewhat varied in character and widely distributed over the State. They occur in strata of

*Am. Chem. Jour., 1897, *19*, 803.

Cretaceous age in Corsicana, Bexar and Medina Counties, both heavy and light oils being found. In Corsicana, the first oil field of any scale opened in the State; and in Bexar, rather heavy oils occur, while in Medina County oil carrying as much as 32% of illuminants has been produced.* The largest additional supplies of petroleum are found in strata of Tertiary age in the Neocene in Jefferson County, on the Gulf Coastal Plain,† where the Beaumont developments were made in 1891, although the exact age of the latter has not been definitely determined, and in the Sour Lake district in Hardin County. The production of petroleum in Texas was not one of industrial importance before 1898, when over half a million barrels were obtained from the Corsicana field. In 1901 the well-known Beaumont or Spindle Top pool was discovered, and over three and one-half million barrels of petroleum of quite a different character from that of the Corsicana field was the record for that field for that year, becoming nearly seventeen and one-half million barrels in 1902, after which there has been a very rapid drop until the production of 1904 only equaled that of 1901. The Sour Lake field, in connection with the Saratoga field produced in 1903 nearly nine million barrels and the Batson Prairie field nearly eleven million barrels in 1904, although less than five million barrels in 1903. In 1904 a pool was opened in a locality, furthest to the South-west of the State, eighty miles from Houston, in Matagorda County, which produced 151,936 barrels of dark-green petroleum of .9393 to .9333, 19.0° to 20.0°B.‡ In Harris County a new pool, known as the Humble field, was also opened in that year, which possesses some interest. . Other pools producing oil of from .8140 to .9032, 40.2° to 25.0°B., are in existence and may be identified as follows:

Bexar County District: Only a small quantity of heavy petroleum was produced in 1902. It came from wells six hundred to eight hundred feet in depth, near San Antonio, and supplied a small local demand. This is not of industrial importance.

*The University of Texas Mineral Survey,, Bulletin No. 1, July, 1900, p. 36.

†Contributions to Economic Geology, U. S. Geol. Survey, C. W. Hayes, 1902, p. 345.

‡ Mineral Resources, U. S. Geol. Survey, 1904, p. 713.

Nacogdoches County: Numerous shallow wells were drilled prior to 1895 near Oil Springs, in Nacodoches County, some twelve miles South-west of the town of Nacodoches. There has been a considerable outlay in drilling wells, establishing receiving tanks, and building a pipe line, all of which has been practically abandoned. Only a very limited quantity, supplying a local demand, is now marketed.

Brazoria County: At Kaiser Hill, near Columbia, Brazoria County, petroleum of good lubricating qualities has been developed, which, owing to a lack of transportation facilities, was not operated during 1904.

South Basque District: At South Basque, McLennan County, seventy miles South-west of Corsicana, oil is produced of .8140 to .9032, 42.0° to 25.0° B.

Henrietta District: At Henrietta, Clay County, one hundred and fifty miles North-west of Corsicana, 65,455 barrels were produced in 1904, having a gravity of .8589, 33.0°B. This oil is said to have a paraffine base,* and to yield the following percentages of distillates in the laboratory:

Naphtha	9.1%
Water-white oil	55.0
Solar oil	13.6
Heavy distillate, asphalt, water and loss	22.6

The total production of the State in 1904 was 22,241,413 barrels, making it rank after California, and second in its pro-

*loc. cit.

†C. F. Mabery & D. M. Buck, "On the Hydrocarbons in Heavy Texas Petroleum." J. Am. Chem. Soc., 1900, *22*, 553.

C. F. Mabery, "Composition of Texas Petroleum." J. Am. Chem. Soc., 1901, *23*, 264.

Clifford Richardson, "Notes on Texas Petroleum." J. Soc. Chem. Ind., 1900, *19*, 121.

Clifford Richardson & E. C. Wallace, "Petroleum from the Beaumont, Texas, Field." J. Soc. Chem. Ind., 1901, *20*, 690.

Clifford Richardson & E. C. Wallace, "On the Occurrence of Free Sulphur in Beaumont Petroleum." J. Soc. Chem. Ind., 1902, *21*, 316.

W. B. Phillips, Texas Petroleum, 1900, The University of Texas Mineral Survey, Bulletin No. 5, December, 1902.

F. C. Thiele, "Texas Petroleum," Am. Chem. Jour. 1899, *22*, 489.

duction in the United States, although third as a field. In the value of its output it was sixth.

The petroleums from the Beaumont, Corsicana and Sour Lake fields have been examined in some detail by several investigators.†

Corsicana Field: The petroleum of the Corsicana field is of two kinds, heavy and light oil, the lighter having a gravity of .8459 to .8235, 35.5° to 40.0°B., while the heavier is much denser.

The writer, in 1900, examined the lighter oil from the field, obtained at a depth of about 1,050 feet, with the following results:

CORSICANA OIL.

Specific gravity, 20/20°	.8457
Beaumé	35.5°
Flash	Ordinary temp.
Volatile 100°	10.8% (Naphtha)
" 160°, 7 hours	35.7
" 200°, 5 hours	11.2
Total	57.7

Residue after heating at 160° flows readily at 21°. Has the appearance of containing paraffine. After heating to 200°, residue has a quick flow at 25°.

Original oil distilled at 25 mm. Pressure.

Fraction	% Distilled	Color	Sp.Gr. 20/20°	Refractive Index at 20°
Crude oil	——	Dark-reddish-brown, green fluorescence	——	——
Atmos. 57-160°	4.0	Colorless	.7396	1.415
25 mm. 53-90	6.2	"	.7611	1.423
90-118	7.4	"	.7829	1.436
118-151	10.4	"	.8018	1.447
150-175	10.8	"	.8187	1.458
175-180*	5.0	"	.8368	1.464
Residue	50.8	Reddish-brown	.8968	——
Loss	5.4	Paraffine	——	——

* Cracking begins.

Distilled at 25 mm. Pressure after Treatment.

Fraction	Color	Loss with NaOH	Loss with H_2SO_4	Sp Gr. 20/20°	Refractive Index at 20°
Atmos. 67-160°	Colorless	3.5%	2.9%	.7337	1.417
25 mm. 58-90	"	2.6	2.3	.7597	1.430
90-118	"	3.1	2.2	.7796	1.438
118-151	"	1.2	1.4	.7939	1.445

151-175	"	3.1	3.0	8132	1.458
175-180	"	4.2	7.2	.8353	1.464
Residue	Light reddish-brown, green fluorescence	——	15.8	.8960	1.494

It appears that this oil is slightly denser than that from the Ohio field, contains paraffine scale, and that the lighter distillates are of a character suitable for illuminants, corresponding with similar components of Ohio oil. This petroleum is, in fact, refined in large amounts most satisfactorily.

According to Thiele* the distillates obtained from it are:

	Distillates.	Sp. Gr.
Naphtha	10.8 %	.710
Kerosene	54.5	.796
Residue	34.7	.905

The residue of the Corsicana oil contains paraffine scale but is to a large extent asphaltic. None of the distillates, however, separate any paraffine in a freezing mixture.

An examination of the residue by the writer, according to the method which has been previously described, resulted as follows:

CORSICANA RESIDUUM.

Physical Properties.

Specific gravity, 25/25°	.9473
Flash	204°

Chemical Characteristics.

Loss, 160°, 7 hours	2.6 %
Character of residue	Soft.
Loss 200°, 7 hours (fresh sample)	7.0 %
Character of residue	Soft.
Bitumen insoluble in 88° naphtha, air temperature—pitch	6.9 %
Per cent. of soluble bitumen removed by H_2SO_4	16.8
Per cent. of solid paraffines	4.8 %
Residue left after heating at 200° for 12 days	72.6 %
Penetration of residue at 25°	45

The residuum contains decidedly less paraffine scale than Eastern, Colorado or even Kansas oils, but contains about the same amount of stable hydrocarbons unattacked by acid.

*loc. cit.

The Sour Lake field produces a much denser oil, .9722 to .9211, 14.0° to 22.0°B. A sample of gravity .9459, 18.0°B., obtained in 1900, has been examined by the writer with the following results:

SOUR LAKE OIL.

Specific gravity, 20/20°	.9458 (Contains water)
Beaumé	18.0
Volatile, 100°	22.8%
Character of distillate.	Water with trace of oil.
Volatile, 160°, 7 hours (dry oil)	12.6%
" 200°, 5 hours	14.4
Total	49.8

Residue after heating to 160°, flows readily at 21°, asphaltic, pulls to a long string. After heating to 200°, residue flows quickly at 25°.

Result of Distillation of Original Oil at 25 mm. pressure after removing water.

Fraction	% Distillate	Color	Sp.Gr. 20°	Refractive Index
Crude oil	——	Reddish-brown, green fluorescence	——	——
100-150°	6.6%	Light yellow	.8693	1.474
150-170	12.7	Light green-yellow	.8957	1.489
170-175*	2.6	" " "	.9056	1.500
Residue	78.1	Reddish-brown maltha very sticky	——	——

* Cracking begins.

The fractions showed no paraffine at 0°. The residue appears free from paraffine and is strongly asphaltic.

Result on Treatment with Reagents.

Fractions	Color	Loss with NaOH	Loss with H_2SO_4	Sp.Gr. 20°	Ref. Ind. 20°
100-150°	Colorless	3.0%	1.5%	.8623	1.475
150-170	"	1.7	3.2	.8879	1.490
170-175	"	5.0	10.0	.8960	1 495
Residue	Light-reddish brown	——	18 2	.9432	1.521

In an open dish 35% of this oil was volatile in seven hours at 200°, leaving a soft asphaltic residue, but on distillation under a pressure of 25 mm. but 21% was volatilized before cracking began. No paraffine could be separated from the distillates, and that boiling between 100 and 150°, at 25 mm., had the following ultimate composition:

Carbon	85.9%
Hydrogen	14.0

This is a much larger percentage of hydrogen than is present in the asphaltic oils of California. A comparison of the distillates from the Corsicana, Sour Lake and California oils is of interest:

SPECIFIC GRAVITY.

	Distillate at 25 mm.					
	Corsicana.		Sour Lake.		California. Fullerton Oil.	
	Before treatment.	After treatment.	Before treatment.	After treatment.	Before treatment.	After treatment.
50-100°	.7611	.7337	.....	.....	.8745	.8169
100-150	.7932	.7853	.8693	.8623	.9195	.8593
150-175	.8187	.8132	.9056	.8960	.9547	.8774

The hydrocarbons of the same boiling point in California oil are of an enormously higher density than either of the Texas distillates, thus differentiating them very sharply, while this is emphasized by the character of the residuum of the different oils, that from California being much less stable that the Texas residuum.

Percent of Residuum in Naphtha Solution Removed by Strong H_2SO_4.

Fullerton, 1899	33.8%
Summerland, 1894	25.8
Sour Lake, 1859	18.2
Corsicana, 1899	15.8
Ohio, 1897	13.6
Pennsylvania, 1897	10.5

Since 1900 the Sour Lake oils have been sunk to a greater depth and a much lighter oil obtained than that examined by the writer. The character of the petroleum from this field may, to-day, be of somewhat different nature.

A petroleum which has attracted a great deal of attention is that from the celebrated Beaumont field, or Spindle Top pool, in Jefferson County. This has been examined by many chemists and in some detail by the writer. His results are as follows, in comparison with those for Pennsylvania petroleum;

ULTIMATE COMPOSITION.

	Beaumont, Texas.	Pennsylvania*
Carbon	85.03 %	86.10 %
Hydrogen	12.30	13.90
Sulphur	1.75	.06
Oxygen and Nitrogen	.92	
Loss on treatment with excess of H_2SO_4	39.0 %	21.0 %

*Engler.

PHYSICAL PROPERTIES.

	Beaumont.		Pennsylvania.
Specific gravity, 25/25°	9.12	.9.14	.8014
Flash	Ord. temp.	43°	Ord. temp.
Viscosity		75″	37″

VOLATILITY IN OPEN DISH.

110° 7 hours	19.19 %	20.0 %	47.3%
160°, "	21.21	27.0	58.0
205°, "	57.57	49.0	68.0
To Constant Weight:			
105° 42 hours	48.0	48.0	58.7
160° 70 "	64.0*	57.0	71.8†
205° 49 "	74.0	74.0	84.0

*49 hours. †42 hours.

VISCOSITY OF RESIDUES.

205°, 7 hours	Quick flow.	Quick flow.	Soft.
205°, 49 hours	Solid.	Solid.	Brittle pitch.
Penetration	10	8	

DISTILLATION—ENGLER'S FLASKS.

	Beaumont.	Pennsylvania.
Distillation begins	110°	80°
Below 150°	2.5 %	21.0%
150-300	40.0	41.0
300-350	20.0	14.0
350-400	25.0	23.0
Loss on acid treatment (150-300 fraction)	10.0	1.8
250-260	30.0	....
Loss on acid treatment	8.0	....
Percentage of acid used	7.0	2.5

SPECIFIC GRAVITY AND REFRACTIVE INDEX.

	Beaumont.		Pennsylvania.	
Below 150°	Amount too small.		.7188	1.415
150-300	.8749	1.473	.7984	1.437
300-350	.9084	1.501	.8338	1.462
350-400	.9182	1.508	Paraffine.	1.470

AFTER ACID TREATMENT.

150-300°	.8704	1.473	.7791	1.438

The residue, amounting to 9.9% of the original oil, was evaporated in an open dish to 6%—it was then a brittle pitch which had the following properties:

Specific gravity, 25/25°	1.0454
Color	Black
Lustre	Shiny
Structure	Massive
Fracture	Conchoidal
Hardness—penetration	15
Bitumen soluble in CS_2, air temperature	99.8 %
Organic matter insoluble	.1
Inorganic or mineral matter	.1
	100.0
Soluble in 88° naphtha, air temperature	60.0 %
Per cent. of total bitumen soluble	60.1
Soluble in 62° naphtha	64.8 %
Per cent. of total bitumen soluble	64.9
Bitumen yields on ignition:	
Fixed carbon	21.13

A similar, but softer pitch, made by boiling crude oil for twenty hours in an open dish, had the following properties, as compared with a "D" grade residue, or paving asphalt, from Los Angeles, California, oil.

	Beaumont, Texas.	Los Angeles, California.
Penetration at 25°	78	78
Specific gravity, 25/25°	.9943	.9964
Bitumen soluble in 88° naphtha, air temp.	78.3%	74.4%
Bitumen soluble in 88° naphtha,	84.3%	81.6%
Fixed carbon	8.7 %	15.0 %

FRACTIONAL DISTILLATION.

Fraction.	% Distillate.	Sp. Gr. 26°	Refractive Index.
Atmos. Pres.:			
149-205°	1.0 %	.8114	1.459
205-227	8.4	.8408	1.461

227-249	4.4	.8569	1.467
249-271	10.8	.8705	1.476
271-293	10.8	.8863	1.485
293-317	13.1	.9009	1.492
20 mm. Press.:			
200-240°	13.0	.9184	1.505
240-280	8.8	.9349	1.514
280-320	10.6	.9429	1.521
Total	80.9		

Residue, heavy, slow flow at 21°.
Difference in boiling point for 760 mm. pressure 117°.

EFFECT OF REAGENTS ON DISTILLATES.

Fractions.	Removed.	Specific Gravity after treatment.	Refractive Index 20°
	Excess of strong H_2SO_4.		
205-227°	7.7 %	.8357	1.463
249-271	17.8	.8497	1.474
293-317	21.6	.8929	1.486
	Excess of H_2SO_4 + HNO_3 after H_2SO_4.		
293-317°	11.0	.8879	1.483

Total oil removed by reagents, 32.6 %

EXAMINATION OF THE PRECEDING RESULTS.

From the preceding results it appears, although the two specimens are slightly different in their specific gravity and flash point, that the Beaumont oil has a very high density for one beginning to distill at 110°, and that the hydrocarbons of which it is composed, as shown by the ultimate composition of the original oil, and by a comparison of the specific gravity and refractive index of the 150-300° distillates from the Engler flasks with similar distillates from Eastern oils, must belong largely or entirely to some series other than the paraffine, and probably to the same series as those found in the Sour Lake petroleum which we have previously examined (J. S. Chem. Ind., 1900, *19*, 121.), rather than those of the Corsicana oil, which consists largely of paraffines. It is also plain that the oil contains a much larger proportion of unsaturated hydrocarbons removable by sulphuric acid than Pennsylvania petroleum. The Beaumont oil has a high sulphur content and carries, as it comes from the wells, a large amount of hydrogen sulphide in solution. This gas has previously been observed

in solution in petroleum, but not in so large quantity as at Beaumont. The sulphuretted hydrogen is largely lost on standing and more completely on blowing air through it. After such treatment the oil contained 1.75% of sulphur in the form of sulphur derivatives of the hydrocarbons, and as free sulphur.*

Mabery† has examined in detail fractions of this oil where heaps occur at certain temperatures on continued distillation, with the following results:

Fractions.	Distillates.
760 mm. Pressure:	
145-200°	4.0 %
200-250	11.0
14 mm. Pressure:	
95-100°	17.0 %
150-200	17.0
250-300	51.0
Residue	15.0
	100.0

Fraction.	Symbol.	Sp. Gr. 20°	Carbon.	Hydrogen.	Ref. Ind.
130-135°	$C_{12}H_{22}$	.8553	86.86 %	13.27 %	.....
155-160	$C_{14}H_{26}$	.8746	86.26	13.48	1.473
190-195	$C_{16}H_{22}$	.8915	87.26	12.54	1.484

It appears that these hydrocarbons belong to the C_nH_{2n-2} series and undoubtedly, at higher boiling points, are of the C_nH_{2n-4} series.

The heavy fluxes, or oily residuums from Beaumont oil, where the distillation is stopped before the production of a residual pitch, have the following characteristics:

HEAVY RESIDUUM—BEAUMONT, TEXAS.

PHYSICAL PROPERTIES.

Specific gravity, 25/25°	.9735
Flash	214°

CHEMICAL CHARACTERISTICS.

Loss, 160°, 7 hours	.8 %
Character of residue	Soft.
Loss, 200°, at 7 hours (fresh sample)	6.2 %
Character of residue	Soft.

*J. Soc. Chem. Ind., 1902, *21*, 316.

†loc. cit.

Bitumen soluble in CS_2, air temperature	99.6 %
Organic matter insoluble	.4
Inorganic or mineral matter	.0
	100.0

Bitumen insoluble in 88° naphtha, air temperature—Pitch	4.8 %
Per cent. of soluble bitumen removed by H_2SO_4	20.9
Per cent. of total bitumen as saturated hydrocarbons	79.4
Per cent. of solid paraffines	1.7
Fixed carbon	3.5 %

On comparing this residuum with that prepared from California oil it is seen to be less dense and to differ from it in such a way as to show that the hydrocarbons of which the two are composed are quite different. It is worthy of note that it contains an appreciable percentage of solid paraffines. The Beaumont petroleum, therefore, contains not only the hydrocarbons of the various polymethylene series but also some of the C_nH_{2n+2} series.

As the oil is distilled industrially, a much larger percentage of residual pitch is obtained than by gradual distillation at reduced pressures in the laboratory, in which respect the oil differs entirely in its behavior from that from California fields, where a much smaller percentage is obtained industrially. The industrial pitch has the following characteristics:

RESIDUAL PITCH FROM TEXAS, BEAUMONT, OIL.

PHYSICAL PROPERTIES.

Specific gravity, 25/25°	1.0803
Color of powder or streak	Black
Lustre	Lustrous
Structure	Uniform
Fracture	Semi-conchoidal
Hardness, original substance	-1
Odor	Asphaltic
Softens	110°
Flows	119°
Penetration at 25°	13

CHEMICAL CHARACTERISTICS.

Loss, 160°, 7 hours	.13 %
Character of residue	Smooth

Loss, 200°, 7 hours (fresh sample)	.19 %
Character of residue	Smooth
Bitumen soluble in CS_2, air temperature	99.0 %
Organic matter insoluble	.8
Inorganic or mineral matter	.2
	100.0

MALTHENES:

Bitumen soluble in 88° naphtha, air temperature	65.4 %
This is per cent. of total bitumen	66.1
Per cent. of soluble bitumen removed by H_2SO_4	32.1
Per cent. of total bitumen as saturated hydrocarbons	44.8
Bitumen soluble in 62° naphtha	71.5 %
This is per cent. of total bitumen	72.2

CARBENES:

Bitumen insoluble in carbon tetrachloride, air temperature	5.1 %

BITUMEN YIELDS ON IGNITION:

Fixed carbon	24.0 %
Paraffine scale	1.2 %

It is of interest to compare this residual pitch with that prepared from California petroleum. Its most striking characteristic is the presence of from one to 2% of paraffine scale, derived from the original oil. The percentage of fixed carbon which it yields is considerably higher than is obtained with the California petroleum, although a higher percentage would be found in the latter were the distillation carried to the same extremity. It contains a larger percentage of hydrocarbons unattacked by acid.

OTHER FIELDS.

Petroleums from some of the other fields in Texas resemble in part that from the Corsicana field, and more that from the Beaumont field. The heaviest oils are, however, quite widely distributed, especially in the shallower wells. In the Saratoga district the oil is of a density of from .9722 to .9333, 12.0 to 20.0°B.; in the Batson Prairie district .9150 to .9091, 23.0 to 24.0°B.; in the Matagorda pool .9396 to .9333, 19.0 to 20.0°B.; while the lighter petroleums .9150 to .8140, 23.0 to 42.0°B.,

are found in the South Basque, Henrietta, Batson Prairie and a few minor districts. None of these oils has been examined in detail.

From the preceding data it appears that there is a very great variation in the character of the petroleum which is produced in Texas. All of the Texas oils contain some paraffine scale and in all cases leave a larger or smaller amount of asphaltic residue. The heaviest petroleums, however, differ essentially in the character of their higher boiling hydrocarbons, from California oil.

KANSAS FIELD.

The Kansas oil field covers a large area and extends into Oklahoma and Indian Territories. The petroleum is of very varied character, but much of it has a density of .8750, 30.0°B., and less, and is very desirable for refining purposes. About one million barrels was the output of 1903, but development has been so rapid that this exceeded 4,500,000 barrels in 1904 in Kansas alone, while over 1,300,000 barrels were produced in Indian Territory and Oklahoma in that year. The wells are from 350 to 1,500 feet deep and the oil is found in sands whose horizons are not known to the writer. It would seem that eventually this field will be connected with that of Texas.

A typical Kansas oil of .8750 gravity, 30.0°B., received in 1901 from the Federal Gas & Oil Company, Cherryvale, Montgomery County, was examined by the writer with the following results:

Specific gravity, 25/25°	.873
Flash	32°
Volastile, 105°, 7 hours	21.4%
" 160°, 7 " (fresh sample)	33 6
" 200°, 7 " (" ")	47.9
Character of residue at 200°	Soft
Volatile, 160°, to constant weight	47.4%
Character of residue	Soft
Volatile at 200°, to constant weight	50 4 %
Character of residue	Soft—paraffine

Distillation in vacuo 20 mm. Pressure.

Fraction	% Distillate	Sp.Gr. 20°	Ref. Index	Remarks
60-80°	3.2	.7637	1.425	Light straw color
80-100	2.8	.7683	1.428	" " "
100-120°	4.3	.7814	1.434	" " "
120-140	6.0	.8008	1.443	" " "
140-160	8.1	.8209	1.454	" " "
160-180	5.1	.8382	1.462	" " "
180-200	5.7	.8489	1.469	" " "
200-220	7.0	.8608	1.475	" " "
220-240	5.1	.8911	1.482	Solid .0° Crystalline paraffine
240-260	6.2	Boiled over		do.
260-280	12.5	" "		Rich in paraffine
280-300	4.2	.8963	1.498	Solid

The higher distillates in this oil separate paraffine and the residue is of a distinctly paraffine nature. The distillates correspond in character to those obtained from the Trenton limestone petroleum of Ohio, and show that the hydrocarbons contained in the oil must, in addition to the paraffines, consist of the same series found in the latter oil, that is to say, the C_nH_{2n-2} and C_nH_{2n-4} series.

These oils are collected by the pipe lines and refined at Neodesha, Kansas, while additional lines now carry them to Whiting, Indiana, for treatment at the refineries of the Standard Oil Company. The characteristics of the residuum produced at the Neodesha refinery are as follows:

PHYSICAL PROPERTIES.

Specific gravity, 25/25°	.9328
Beaumé	20.5
Color	Brown
Odor	Petroleum
Flash	196°

CHEMICAL CHARACTERISTICS.

Loss, 160°, 7 hours	2.6 %
Character of residue	Soft.
Loss, 200°, 7 hours (fresh sample)	5.7 %
Character of residue	Soft.

Bitumen insoluble in 88° naphtha, air temperature—Pitch..... 3.6 %
Per cent. of soluble bitumen removed by H_2SO_4.....14.4

Per cent. of solid paraffines..... 7.8 %

Fixed carbon ..... 4.1 %

The residue from the distillation of Kansas oil reveals its mixed character by the paraffine scale which it contains and the higher fixed carbon which it yields.

The Kansas oil is becoming an important factor in the petroleum industry in the United States. The wells have very considerable staying qualities and some of those in the territories are large producers even as compared with some of the gushers of the old eastern fields. It is, of course, denser than any of the eastern petroleums, as a rule, but differs from the Ohio oil in being comparatively free from sulphur compounds. Like the Ohio oil the higher distillates are very rich in paraffine scale.

LOUISIANA FIELD.

Within the last four years Louisiana has made a decided record as a petroleum producing State, the output for 1904, 6,611,419 barrels, making it the eighth in rank among the producing States, while but a little over half a million barrels were produced in 1902.

Petroleum has been found at a number of points in the State but the principal field is at Jennings, and twelve miles west of there, which is known as the Welsh field. The other localities have not been largely developed.

The production of the Jennings field in 1904 was 2,905,507 barrels, while that of the Welsh field was over 35,892 barrels, and this has been largely increased since that date, amounting to sixty thousand barrels per day at the beginning of 1905. The oil occurs in similar geological horizons as that of Texas, and the two fields may be considered as virtually one.

The petroleum has been examined by Charles E. Coates and Alfred Best* who present the following data:

*J. A. Chem. Soc., 1903, 25, 1153.

	Texas.	Louisiana.		
	Beaumont.	Welsh.	Jennings.	Beaux Bridge.
Sp. Gr., 25°	.9228	.9276	.9093	.9392
Distillation, Engler Flask, 760 mm. to				
-150°	None.	None.	None.	None.
150-200	2 %	"	"	"
200-250	8	2 %	13 %	1 %
250-300	26	17	28	15
300-350	26	23	24	22
Estimated depth of well (feet)	1200	700(?)	1000	600
% of sulphur in crude oil.	1.95	0.32	0.39	0.20

It appears from the preceding data that the Louisiana oil carries much less sulphur than the Beaumont oil and that the Jennings oil is of a lower density and gives a greater percentage of distillates below 300°. Denser oil occurs outside of the Jennings field. In the latter, distillates have been isolated consisting of the C_nH_{2n-2} and C_nH_{2n-4} series of hydrocarbons corresponding to the following formula and having the following specific gravity and boiling point:

Oil from Jennings Field. 60 mm. Pressure.

Fraction	Symbol	Specific Gravity
110-115°	$C_{12}H_{22}$	.8479
160-165	$C_{14}H_{26}$	.8785
210-215	$C_{17}H_{30}$	.9009

The distillation of the lowest boiling point is characterized by an odor strongly resembling turpentine, so that it is sold as a turpentine substitute.

Coates and Best have also examined the distillates from the Jennings and Welsh oils boiling below 300°. In the Jennings oil three fractions were obtained which, after treatment with H_2SO_4, have the following characteristics:

Oil from Jennings Field.

Fraction	Pressure	Symbol	Sp.Gr.	Ref. Ind.	Remarks
110-115°	80 mm.	$C_{11}H_{20}$	.8373	1.4535	Odor of turpentine
150-155	"	$C_{13}H_{24}$	.8649	1.4692	No odor
200-205	"	$C_{16}H_{28}$	.8801	1.4805	——

Oil from Welsh Field.

145-150°	80 mm.	C_{12} H_{22}	.8551	1.4662	——
165-170	100 "	C_{13} H_{24}	.8679	1.4666	——
175-180	33 "	C_{17} H_{32}	.8736	1.4760	——

The second fraction from both of these oils agrees quite closely in their characteristics with that from the Summerland, California, oil of corresponding boiling point separated by Mabery.

	Fraction.	Pressure.	Sp. Gr.	Ref. Ind.
Summerland, Cal.	150-155°	60 mm.	.8621	1.4681
Jennings, La.	150-155 %	80 "	.8649	1.4692
Welsh, La.	165-170 %	100 "	.8679	1.4666

All the fractions consist of hydrocarbons which have a composition corresponding those of the C_nH_{2n-2} series, with the exception of the third, from Jennings oil, which is less rich in hydrogen and corresponds in composition to one belonging to the C_nH_{2n-4} series.

In another very heavy oil having the following characteristics, from Bayou Bouillon, similar distillates were examined by Coates:

Specific gravity..... .9669
Distillation begins.....275°
Fraction at 300°.....11.0%
Sulphur..... .57 %

Fraction.	Pressure.	Sp. Gr.	Ref. Index.	Symbol.
140-145°	33 mm.	.8557	1.4691	C_{12} H_{24}
170-175	"	.8871	1.4820	C_{14} H_{28}
190-195	"	.8966	1.4883	C_{15} H_{30}
200-205	"	.9006	1.4916	C_{16} H_{32}
225-230	"	.9104	1.4972	C_{19} H_{34}

With the exception of the first fraction these distillates contain hydrocarbons belonging to the C_nH_{2n-4} series.

It is evident that the Louisiana petroleum, except in the smaller amount of sulphur which it contains, has a very considerable resemblance to Beaumont oil, and this is not surprising when the geographical and geological location of the two fields is considered.

ALASKA FIELD.

Petroleum has been found in a number of localities in Alaska, the most important of which are known as the Con-

trollers Bay, Cook Inlet and Cold Bay fields,* but nothing of industrial importance has been developed in any of them, although a number of wells have been sunk at various points.

A seepage from Cold Bay, Cook Inlet, in 1903, was found by the writer to have a density of .989, 11.6°B. It left on heating 72.3% of an asphaltic residue, having a penetration of 27, which contained 2.7% of paraffine scale solid at 40°, and yielded 12% of fixed carbon on ignition. Such petroleum corresponds closely to some of those found in Texas. In the publication cited, data in regard to petroleums from the same field are given, which are of some interest.

Report of Tests of Oil from Oil Bay and Cold Bay.

	Oil Bay	Cold Bay
Specific gravity at 16°	.9557 = 16.5°B.	.9547 = 16.6°B.
Distillation by Engler method :		
Initial boiling point.	230°	225°
Burning oil (distillation up to 300° under atmos. pressure).	13.2% = 25.9°B.	13.3% = 29.6°B.
Lubricating oils (spindle oils) 120 mm. pressure up too :00°).	39.2 = 22.6°B.	28.3 = 23.8°B.
Lubricating oils (120 mm. pressure, 300-350°).	19.6 = 16.9°B.	18.3 = 18.0°B.
Paraffine oils (by destructive distillation under atmospheric pressure).	22.4 = 20.4°B.	32.0 = 20.4°B.
Coke and loss.	5.6	8.1
Total sulphur.	.098	.116

These data fail to bring out the fact that the oils are largely of an asphaltic nature, but show that the percentage of sulphur is not large. The initial boiling point is, in both oils, very high, and this, together with the high density, would point to the fact that they can never be of great industrial importance as far as the production of illuminants is concerned.

Petroleums from other localities in Alaska have not been examined as far as the writer is aware, but they are probably of the same character as that from the Cold Bay field.

CUBAN FIELD.

The native bitumens occur widely scattered over the Island of Cuba, but industrially, only the solid forms have been de-

*Report on Progress of Investigations of Mineral Resources of Alaska in 1904, Washington, Government Printing Office, 1905.

veloped, grahamite and asphalt. Indications of petroleum have been found in all the Provinces with the exception of Puerte Principe, and various attempts have been made to sink wells, but so far without results. In the Province of Santa Clara there is an occurrence of extremely light oil. At the Motembo well a colorless naphtha occurs which it is difficult to believe is a natural product. Near the town of Santa Clara an amber-colored petroleum of specific gravity .901, 25.4°B., is found floating upon the surface of a stream of water, having an agreeable odor, like cedar wood. Most of the petroleums in Cuba, however, are extremely dense or in the form of maltha, having an asphaltic base, and a density of from .95 to 1.05, 17.4° to 10.0°B. A number of samples of this material have been examined by the writer. The following are data characteristic of one of these malthas:

MALTHA FROM HATO NUEVO, MATANZAS PROVINCE, CUBA.

Specific gravity, 25/25°	1.0466
Loss 100° to constant weight	6.2%
Consistency of residue	Soft.
Loss 160°, 7 hours	6.8%
Penetration of residue at 25°	55
Loss 200°, 7 hours (fresh sample)	11.9 %
Penetration of residue at 25°	18
Bitumen soluble in CS_2, air temperature	98.6%
Organic matter insoluble	.7
Inorganic or mineral matter	.7
	100.0
Per cent. of total bitumen:	
Soluble in 88° naphtha, air temperature	75.5%
Soluble in 62° naphtha	83.7
Fixed carbon	11.0 %

A lighter oil is found in Santa Clara Province having the following characteristics:

Specific gravity, 25/25°	.944
Beaumé	18.3°

Loss 100° for 1 hour	1.5 %
Total loss 160°, 7 hours	18.5 %
Character of residue	Soft.

None of the petroleums of Cuba can be of great industrial importance for the production of illuminants and, although it is not impossible that material may be obtained in large quantity after proper exploitation, it would prove, in all probability tc be asphaltic and could only be made available for use as fuel.

MEXICAN FIELD.

Indications of the occurrence of petroleum are frequent along the coast line of the Gulf of Mexico, and especially in the neighborhood of Tampico. A large number of samples of this material have been examined by the writer and found to be of very great density and of an asphaltic nature, in this respect resembling the oil found in Cuba. The character of the petroleum, in general, is revealed by the following data:

PETROLEUM FROM WELL AT CHAPAPOTE.

Specific gravity, 25/25°	.9604
Loss at 110°	10.4 %
" " 160	23.4
" " 200	6.8
Penetration of residue at 150°	70
" " " 200°	18
Bitumen soluble in CS_2, air temperature	99.8 %
Organic matter insoluble	.1
Inorganic or mineral matter	.1
	100.0

While lighter oil may be developed on further exploitation, it is evident that the petroleum of Mexico can never be relied upon for the production of highly valuable products, although it may eventually be found in quantity for use as fuel.

COMPARISON OF NORTH AMERICAN PETROLEUMS.

From the preceding data it appears that the petroleums of North America are of a most varied and interesting character. Those of the earlier days of the industry, from the Appalachian

field, were paraffine oils and on this account, and their freedom from sulphur, have been the most valuable obtained in the United States, or in any other part of the world, for the production of illuminants. Although the supply from this field forms a very much lower percentage in the total production of the United States than it has heretofore and, although the production of the field has somewhat diminished, the value of the latter is greater than that of any other field and it will probably occupy this position for many years to come, since it is becoming extended from year to year and new pools are being developed, as is illustrated by the great increase in the production of West Virginia and Kentucky within the last few years.

The petroleum of North-western Ohio and Canada which next appear upon the scene chronologically, being sulphur oils, were far less valuable, not only on this account, but because of the smaller percentage of illuminants, until a process of distillation with copper oxide was discovered which made it possible to secure a satisfactory article. The Ohio field, of late years, has extended into Indiana and is of great importance, not only as regards the value of its products, owing to the possibility of making paraffine illuminants from it, but also on account of the number of barrels produced, in which, in 1904, it ranked third among the North American fields, with 21% of the total production.

Within the last ten years, the development of new fields has modified very largely the aspect of the petroleum industry in North America. California, which produced less than 5% of the entire supply of oil in 1899, in five years has more than quintupled that amount. This oil, however, is composed of such a series of hydrocarbons, of a non-paraffine nature, that its value is comparatively small, being nearly one-third less than that of the oil obtained from the Appalachian field. It does not offer a distillate which is satisfactory as an illuminant when burned by itself.

The oils from the more recently developed fields of Kansas and Texas are of variable character. Although all are more or less asphaltic, they also contain varying proportions of paraffine hydrocarbons, and the lighter oils are proving a vast source of supply of illuminants of a paraffine nature, which

will, no doubt, continue to increase in importance in the future. The more asphaltic oils of the Gulf Coastal Plain of Texas and Louisiana are so strongly asphaltic as to be of value only for the production of lubricants, for use as fuel and as gas oil. They yield practically no paraffine illuminants.

It is also worthy of note that no petroleums have been found in North America of the Russian type, that is to say, consisting preponderatingly of monocylic polymethylenes or napthenes.

The present aspect of the petroleum industry in the United States is a very satisfactory one. With the diminution of the output of paraffine oils in the Appalachian field, there has been an increase in that from the Indiana field, which makes the combined output from the two somewhat larger in 1904 than for that of five years ago, while the strongly paraffine petroleums of the new Kansas and some individual Texas fields have also added to the source of supply of desirable illuminants to such an extent as to be a matter of great importance, and to make the outlook for a continued supply of burning oil at the present time encouraging. The petroleum industry, however, is so kaleidoscopic that it is impossible to say whether there will be as great a change in the aspect in the next five years as there has been in the past. It will be a matter of interest to watch the development which may occur.

Long Island City, New York,
March 15, 1906.

THE MOST POWERFUL LOCOMOTIVE.

What is said to be the heaviest passenger engine ever built has been delivered to the Lake Shore & Michigan Southern Railroad. It weighs 244,700 pounds, of which 170,000 are on the driving wheels. The engine and tender weigh 403,700 pounds and the capacity for water is 7800 gallons, while that for coal is fifteen tons. This powerful locomotive was designed as a step in the development of large passenger locomotives on the Lake Shore road, which began about seven years ago, as a result of which this road has a series of successful designs. The Walschaert gear has been generally adopted because of favorable experience in both freight and passenger service. The new locomotive is entirely free from untried devices or principles.

Mechanical and Engineering Section.

(*Stated Meeting, held Thursday, April 5th, 1906.*)

The Design, Installation and Maintenance of the Modern Office Building.

By Chas. Gobrecht Darrach, C.E., Etc.

(*Concluded from vol. clxii, page 56.*)

SANITATION.

In discussing the subject of sanitation, we must consider not only the purity of the air we breathe and of the water we drink, but also that temperature at which they are best adapted for comfort and health. We must also consider the proper disposal of vitiated air and water or their revivification.

In community buildings as in most private dwellings the imperative problem of proper sanitation is ignored probably more flagrantly than any other.

The system of cleansing has in the past followed the old methods of manual labor. We have now at our command mechanical means, which can be installed not only reducing the cost, but also increasing the efficiency.

In addition, unwholesome and disagreeable odors must be prevented, and stale air replaced with fresh pure air, or the tenants cannot do their work well or with comfort.

It seems like an insult to present day civilization, that this subject should be even mentioned, but (like boiler and engine room conditions) it is systematically neglected, even in the face of both experience and example.

Great stress is laid upon the poisonous effects of the carbon oxides in the atmosphere.

Unfortunately, some recognized sanatarians have minimized

the importance to health, of air free from the other gases of decomposition, and have almost wholly neglected that potent adulteration—an air too highly charged with aqueous vapor.

As an extreme case, but one which, as an example, may be used to illustrate the ill effects of foul air as well as the beneficent results obtained by an improved condition, the speaker would call your attention to an article in the "Engineering Record" of January 22, 1898.

In the institution under consideration the air was so vitiated, that on rising in the morning, the attendants were frequently attacked with violent nausea, and the maladorous atmosphere greeted the visitors at the portal.

The principal cause of the trouble, lay in the vicious design of the toilet hoppers, added to the unscientific system of "*vent*"ilation.

The toilet hoppers were removed and the sanitary hopper hereinafter described was substituted, as well as other modifications in the ventilation system.

The results, as exhibited in the following quotation, speak for themselves.

PNEUMONIA AND SANITATION.

Philadelphia, Pa., January 8, 1898.

"To the Editor of The Engineering Record.

"Sir: As recorded results are always interesting and instructive, the writer would call attention to certain data obtained after having improved the sanitary condition of a children's asylum constructed within the last few years.

"The institution in question has a constant population of over two hundred children from one and one-half to six years of age, eight to ten infants at the breast, and thirteen adults. The individuals, of course, are constantly changing, so that the mortality noted is not proporionately as great as would otherwise appear. The children are gathered from the lower walks of life, and generally, in poor condition when they are placed in the home, many of them having contracted disease and suffering from bad attention, etc.

"During the first year after the institution had been occupied there were *thirty-eight deaths*; during the second year, *sixty-eight deaths*; during the year after the sanitary conditions had been improved there were but *five deaths*. The character of the children in the institution was about the same, but the population during the last year was somewhat greater than previously. As you will note, there was a notable improvement in the general health conditions.

"Following you will find certain tables showing the number of deaths and the causes of mortality. The first table shows diseases and deaths which have been imported, or those not directly attributable to bad sanitation. The second table shows diseases and deaths ordinarily considered as the result of impure air, etc. The third table shows mortality from pneumonia and throat troubles.

TABLE I.

Mortality from diseases which may have been imported or not directly attributable to bad sanitation.

	1895. Before Improvements in Sanitation.	1896.	1897. After Improvements in Sanitation.
Cholera infantum	1	2	1
Marasmus	1	10	1
Convulsions	0	4	1
Convulsions and measles	2	0	0
Spinal caries	0	0	1
Gangrene of face	0	1	0
Gangrene of face and measles	1	0	0
Gangrenous stomititis	1	0	0
Nephritis	2	0	0
Indigestion	1	0	0
Gastro-enteritis	0	1	0
Tuberculosis	1	1	0
Gastro-intestinal catarrh	0	1	0
Total	10	20	4

TABLE II.

Mortality from diseases ordinarily considered as the result of impure air, etc.

Diphtheria and measles	8	0	0
Meningitis	4	14	0
Total	12	14	0

TABLE III.

M ortality from pneumonia and throat diseases.

Pneumonia	2	27	1
Pneumonia, catarrhal	0	1	0
Pneumonia and measles	13	0	0
Membraneous croup	0	4	4
Membraneous croup and measles	1	0	0
Bronchitis	0	2	0

Total	16	34	1
Grand total	38	68	5

"Whether or not bad sanitation was the cause of the great mortality from pneumonia and throat troubles, I am not prepared to say, but when we find, that in the first year of the building's occupancy (1895), we had sixteen deaths from pneumonia and throat diseases in a total of thirty-eight, or forty-two per cent.; in the second year (1896), after the building had been well saturated, thirty-four deaths in sixty-eight, or fifty per cent., and in the year after the improvements had been made (1897) but one in a total death rate of five, it is fair to presume that either pneumonia and throat troubles may be caused by a bad condition of sanitation, or that recovery is prevented in such cases.

"It is not often that an engineer has the apportunity to obtain data which is herewith submitted, but it seems to me that these facts are worthy of serious consideration by both our own and those of the medical profession."

CHAS. G. DARRACH.

An atmosphere too highly charged with aqueous vapor is unsanitary.

It is hardly necessary, for me to remind you of the increase in the mortality which follows each rise, in the humidity of the atmosphere.

We engineers should know the amount of heat required to vaporize water, and that there is no reason that the damp winds, of February, March and August, should not keep the physicians busy, and enrich the graveyards. The perspiration is not absorbed by an atmosphere saturated with moisture. During the winter months the skin is chilled by this damp, cold envelope, and the circulation of the blood in the capillaries retarded—resulting not only in the congestion of blood in the internal organs, but also in preventing that purification due to skin action so necessary to health.

During the summer the delightful coolness of dry air (even when the thermometer indicates a torrid atmosphere) is produced by evaporation of the imperceptible perspiration, and the sweat of a muggy day converted into a refrigerant both healthful and refreshing.

These phenomena are not difficult of apprehension when we remember that 1000 heat units are required to vaporize one pound of water.

Dry air moreover contains a greater proportion of oxygen than air saturated with moisture, consequently the air used in respiration is of richer quality and more reviving to the blood.

The net result of saturated air is depletion of vitality—from direct blood poisoning—congestion and suffocation.

The exhilarating effects of a dry atmosphere, make cheerful hearts and healthy bodies.

Taking into consideration, the density of the atmosphere, in relation to pressure, the amount of oxygen per cube, is greatest on the surface of the earth at the sea level; the weight of oxygen per cube *decreases* with the rise of temperature, as it does, when the air is contaminated with aqueous or other vapors.

Taking as a standard, dry pure air at 70° Fahr. and at the sea level, as containing one hundred per cent. of oxygen; the air at the same temperature and at elevation of 5,000 feet contains but 80 per cent., and at 10,000 feet but 66 per cent. of oxygen at the sea level at 70° Fahr.

The aqueous vapor, mixed with air, supplants the vitalizing oxygen, in direct proportion to the saturation.

However advantageous, and beneficial, it may be to provide, for the clients in our office building, an equitable temperature throughout the entire year, with an atmosphere not only free from gaseous products of decomposition but also free from an enervating aqueous saturation. The speaker doubts if the general public are as yet sufficiently well informed to demand such a plant.

But for auditoriums, sanitoriums and hospitals such conditions should be *enforced.*

Then it would be unnecessary for the physician to send his consumptive patient to the mountains for pure air, free from moisture; but so attenuated that the poor victim, with a weak heart, succumbs to the extra duty demanded. Nature does the best she can with the ghost of the air, respiration becomes more rapid, the heart palpitates, the poor diseased lung and the weak heart have too great a tax. The panacea kills.

In other words suffocation takes place either from an attenuated atmosphere, or from one charged with moisture, as it does when the air is charged with any other poisonous gas; the necessary oxygen not being present.

We, here in Philadelphia, or in any of those cities from which they flee, who can, to escape the torrid and moisture laden air of summer, or the cold and damp Ides of March, could remain at home in the full enjoyment of an atmosphere pure and rich in the life-giving oxygen; if only the knowledge now possessed were utilized.

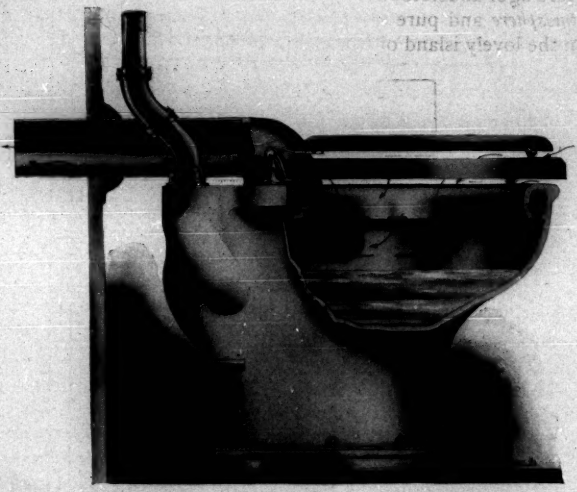
Are we not slow in this twentieth century A. D.? when we do not emulate the great "Hippocrates," who, thousands of years ago, understood, and used, the beneficent work of a *pure atmosphere* and pure water in his sanitoriums and sun parlors on the lovely island of Cos.

Hippocrates

Referring again to the Drexel Building, 1886-'88, this most important question was studied and all the advantages of the then state of the art utilized. Since then, in 1888, if memory is not at fault, a toilet hopper was made (after designs of the author specified for the plumbing in the Pennsylvania Institution for the Deaf and Dumb, at Mt. Airy, Phila.), which had a seat vent above the water line of twelve square inches area. A draught of air is induced, either by a heated flue or fan from the bowl of the closet, not only preventing the possi-

bility of the escape into the room of any objectionable odors, but of ventilating the room by means of the initial receptacle. This style of toilet hopper was also installed in the Reading Terminal R. R. Station Office Building, in St. Vincent's Maternity Hospital and Children's Home, in the Professional Building, in the U. G. I. Office Building and wherever the speaker's influence was sufficient to induce its adoption.

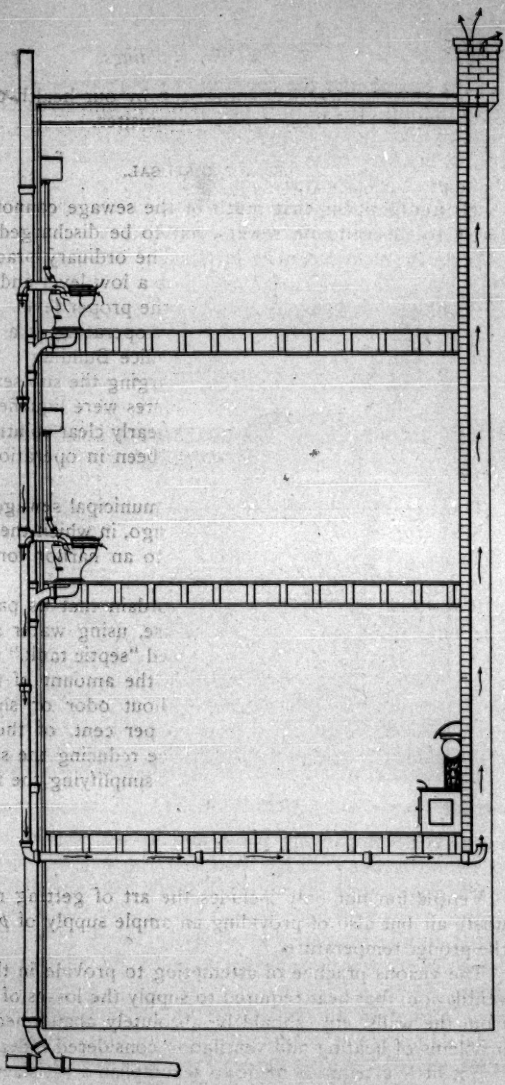
This style of hopper can be installed in private dwellings,



Sanitary Hopper

as shown on accompanying plate, and its use should be enforced by ordinance. It has been on the market eighteen years, but has escaped the notice of sanitarians and municipal authorities. The vent pipes should be carried to the cellar and connected to the kitchen flue—if gas is used in summer a "Bunsen" burner will be sufficient to warm the air and induce the draft.

In the design of all receptacles for decomposing matter, there should always be a sufficient depth of water to submerge the ashes.



Domestic Installation of Sanitary Hopper

The common practice, authorized by our health officers, is to violate both of these sanitary requisites.

SEWAGE DISPOSAL.

It often happens that much of the sewage cannot flow directly to the common sewers, but to be discharged must be raised from their drainage level. The ordinary practice is to conduct all this sewage to a well at a low level and lift it by automatic-pneumatic apparatus to the proper level.

A much less expensive apparatus, operating at a minimum cost, was installed at the U. G. I. Office Building.

This apparatus consisted of discharging the sub-sewage into a septic tank, where the organic wastes were liquefied by natural fermentation and the resultant nearly clear solution pumped to the sewer. This system has been in operation for the past six years without complaint.

The author installed a system of municipal sewage disposal on this principle some twenty years ago, in which the resultant liquefied sewage was discharged into an harbor for pleasure craft.

If the health authorities would ordain that as part of the plumbing installation of every house, using water as a conveyor for sewage, a properly designed "septic tank," the measure of the actual sewage would be the amount of the water supply, the effluent would be without odor or sludge and would contain but from 50 to 60 per cent. of the original organic decomposing matter, at once reducing the size of the sewers, the cost of maintenance and simplifying the final purification.

VENTILATION.

Ventilation not only includes the art of getting rid of the waste air but also of providing an ample supply of *pure* air at the proper temperature.

The vicious practice of attempting to provide in the air for ventilation, that heat required to supply the losses of radiation from the walls, etc., should be absolutely abandoned and the problems of heating and ventilation considered independently.

But little attempt is made to accomplish a satisfactory posi-

tive ventilation in our Community Buildings, one of the systems adopted is to install exhaust fans in the attic and provide exhaust flues to and registers in the offices with an ample supply of fresh air from the corridors.

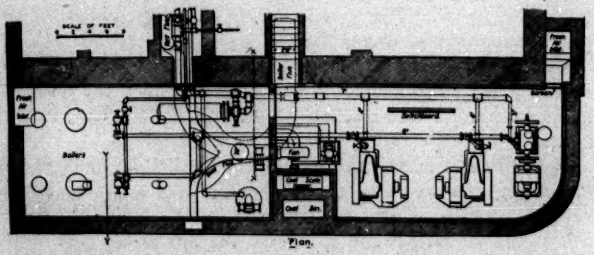
The toilet-room ventilations must be segregated and the air exhausted from the toilet-room hoppers.

In another method, the rooms are heated with fresh hot air and the foul air exhausted.

Most of the recent buildings are content with an omnibus ventilation, from the toilet rooms only.

Any one who has experienced the results can testify to the more healthy and comfortable condition of the well-ventilated building.

As hereinbefore noted, particular attention is again called



Engine and Boiler Room at Art Club, Philadelphia

to the intelligent treatment of the engine and boiler rooms, and at the same time let it be remembered, that even if the municipal laws do not forbid, there is no reason whatsoever that *sirocco from these torture chambers* should be insolently blown on and into those who pass by on the street. The air to ventilate and cool the engine room and to supply air for combustion at the Drexel Building, the Art Club, the U. G. I. Building, and at the Gymnasium, University of Pennsylvania, is drawn from the outside, either by the chimney draft or by fans, and by automatic regulation either passed through the furnaces or directly to the smoke flue, as the steam pressure may require. That this is not difficult is proved at the Art Club, where the smoke flue of necessity took a tortuous path involving 900 degrees of arc.

Even in many of our hospitals and asylums no attempt is made to obtain a pure atmosphere.

In some instances the heating and ventilation are treated together with disastrous results, and in the majority in which the engineer and architect have installed well-designed plants, the management decline to use them.

In hospitals for contagious diseases, each ward should be an *individual, receiving all its air from a pure source* and the foul exhausted air passed through a fire before being discharged to the atmosphere.

This can readily be accomplished by using the fans which exhaust the air, as the blowers to supply air for combustion in the furnaces of the steam boilers used for power and heating.

HEATING.

In all properly designed plants the heating should be by the utilization of the exhaust steam from the prime movers.

The heating in the Drexel Building was with exhaust steam from the engines, supplemented by live steam, as is now the general practice. The distribution was downward two-pipe gravity scheme.

The maximum pressure at the initial one-pound above the atmosphere and the minimum one pound or two inches below.

No air valves were used on the radiators, and automatic check supplanted the ordinary hand valve in the return circulation.

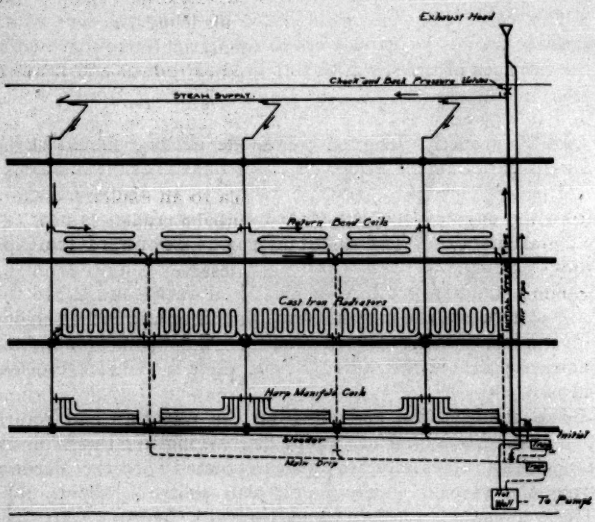
The condensation and air from the radiators and return pipes were conducted into a pipe discharging to a low pressure steam trap. This pipe was also connected with the bleeders from the vertical supply pipes, also controlled by a trap. These connections, before connecting with the traps, were provided with outlets controlled by lock check valves, opening to the atmosphere.

In starting the system and when necessary, the initial pressure is raised above the atmosphere, when, the air in the system being heavier than the vapor of steam, follows the water of condensation, is separated and escapes to the atmosphere through the check in front of the trap.

The Drexel Building has a total cube of approximately 3,000,000 cubic feet, and is ten stories high, and has about

150,000 square feet of rentable floor space, or as much as the Real Estate Building, Philadelphia, or the Empire Building, New York City. It has nearly three times the rentable floor space of the old Land Title Building (Broad and Chestnut) or as there is in the Stephen Girard Building. The circulation of steam was accomplished and the radiators heated in about forty-five minutes.

Contemporaneously and subsequently, this system was used by the speaker in the Trust Company of North America, the



Check value heating system

Reading Terminal Buildings, in the various buildings then erected connected with the University of Pennsylvania, and in other buildings also, and was adopted subsequently by other engineers.

In the Drexel Building the system worked well for four or five years, but as the moulding sand loosened from the inside of the cast iron radiators and collected in the checks, it prevented closing, and the water in the drip pipes was sucked

back into the radiator when the supply valve was closed, by the vacuum produced by the steam condensation.

In using the check valve, water is backed up into the radiator until there is sufficient weight to open the check, so that they should be placed, especially on pipe coils, at a lower level than the radiator.

This gives historically, the first or at least one of the first successful attempts to operate a radiator with the supply valve only—and at or below the atmospheric pressure.

Some time between 1886 and 1888, Alex. de Beaumont, an Alsatian by birth, but resident of Philadelphia, conceived the idea of exhausting the air and condensation from the heating system with a vacuum pump, of at once reducing the dimensions of the supply and drip pipes and valves and dispensing with the troublesome air valve, at the same time reducing the initial steam pressure from five pounds, the then prevalent use, to atmosphere and below.

Unfortunately, he confided this idea to an exploiter, who, I am informed, took it bodily, and patented a crude system called by him the *"Williams Vacuum Heating System."* Mr. de Beaumont was thus deprived of the well deserved reward of his ingenuity.

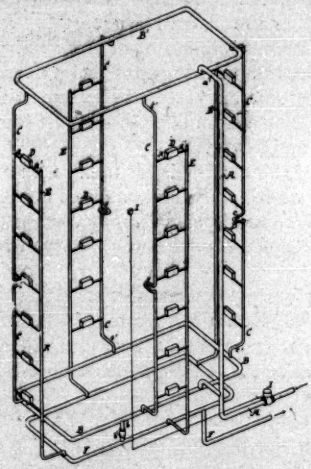
The difficulty in the "Williams" system was this. There being no automatic valve on the radiator drips, short circuits exhausted the nearby radiators and pumped valuable uncondensed vapor to waste, leaving the remote radiators without drainage.

"Williams" sold his patents to "Mr. Warren Webster," under whose guidance the present well-known "Webster Vacuum Heating System" has been put into practical service, fully realizing the hopes of M. Beaumont.

The first plant installed by "Warren Webster" was in 1895-6. The system had merit, and subsequently a large number of plants have been installed. The system, however, at first gave much trouble, and the author was among those who shared in the bitter condemnation for installing this new-fangled scheme. One experience, at the Professional Building, was sufficient to convince the author that to make the system a success, and to take advantage of its merits, we must have clean pipes and radiators, free from the old trouble with the check valve system "moulding sand."

Subsequent specifications by the author required that the radiators must be thoroughly pickled, and absolutely clean before erection; with careful steam fitting the troubles were then over. An example of the latest improvement in steam heating, devised in 1897, may be found in the U. G. I. Office Building, and with your permission I will quote from a paper written by the author and read before the American Society of Civil Engineers in October, 1901.

"Modern practice dispenses with the air-valve and the hand-operated drip-valve, and reduces the size of the pipes by producing a partial vacuum



Double supply heating system

in the drainage system and in the radiators when not in use, so that a flow of steam to the radiators can be maintained below the atmospheric pressure. In the "Webster System" a thermostatic valve takes the place of the hand-operated drip-valve and the air-valve.

"An equal distribution of steam at low pressure, through small pipes, can be readily accomplished by supplying the risers from both basement and attic.

The writer has installed such a system, combined with the "Webster Vacuum System," in the Office Building of the United Gas Improvement Company, a twelve-story building, in which each of the steam supply risers was only 1½ in. in diameter, and served 1600 square feet of radiation. The

steam supply to two radiators, serving fifty-four square feet of surface, did not exceed ¾ in. and the drips from the individual radiators ½ in.

"The amount of steam supplied to the entire heating and ventilating systems serving an equivalent of 20,000 square feet of direct radiator surface, was controlled by a pressure-regulating valve. The temperature of the steam in the radiators under test was regulated to vary from *190 to 260 degrees. The maximum difference in temperatnre between the initial steam in the boiler room and the farthest radiator did not exceed three degrees when the outside temperature was seven degrees Fhr. and the maximum difference was one and a-half degrees when the outside temperature was thirty-one degrees.*

"The pipe sizes in this system were about one-half the areas previously adopted in vacuum systems and one-fourth the areas in gravity systems as laid out by the usual method of supplying the risers from either top or bottom.

"*Using this method of distribution* with the "Webster System," a twenty-four-story building could be served with steam supply risers not over two inches in diameter, and serving from 1200 to 1300 square feet of radiating surface, with a better steam distribution than can be obtained by larger pipes and serving only from one end.

"The double supply system decreases the difficulty in concealing the pipes, decreases the cost of construction in tall buildings, and puts the entire installation under more complete control.

"In one-pipe system a single riser is used both to supply and drain the radiators. The risers are supplied at the top, and drain at the bottom, or may be supplied from both top and bottom. With tight valves and reliable air-valves this system, when aided by positive air exhaust, is fairly satisfactory; but the steam supplied to the radiators is wet, the risers are large, and it is difficult to conceal the pipes and provide for exhaust.

"To obtain good results, and prevent short circuits, with the "Webster System," it may be advisable to run independent drip-mains from certain portions of the system directly to the pumps, and not connect the entire drainage system into one main.

"With the Vacuum System and an equal distribution, the heating system becomes an efficient surface condenser, and, excepting in cases of very severe weather, when a steam pressure above the atmosphere may be required, prevents all back pressure on the engines, and generally produces a slight vacuum.

"The vacuum pump required to remove air and condensation from the radiators requires only a trifling expenditure of power. The author found that the power required to operate an electrically-driven pump on the Vacuum System serving 20,000 square feet of radiating surface, did not exceed two and one-half H. P."

Another advantage of the vacuum system is that there is no danger from leakage, and concealed pipes can be used with safety as the system is generally operated at or under the atmospheric pressure, and if there is leakage, the tendency is

for air to leak into the pipes, rather than for water and steam to escape from them.

The Office Building of the United Gas Improvement Company has twelve stories and an attic above the basement and contains, within the exterior limits, a cube of approximately 1,500,000 feet.

There are in all 650 windows and a large skylight, 16,000 square feet of glass or about 25% of the exterior exposure.

The entire building is ventilated by exhaust fans.

The ventilation of the toilet-rooms being segregated and served by a special fan, exhausting the air from the rooms through the toilet hoppers.

The first story is provided with a supply of filtered and tempered air, and also with an exhaust fan system.

The building above the first floor is ventilated with exhaust fans through ducts and registers, and supplied with fresh tempered air from the corridors. The entire building is heated by direct radiators.

The tempered air is warmed with about 3,500 square feet of semi-direct and indirect radiator coils, etc.

About 13,000 square feet of direct radiators are used to heat the rooms, making a total equivalent to nearly 20,000 square feet of direct radiation.

As all the power for the elevators, for electric lighting, for fans, pumps, etc., etc., is generated by gas engines, and the heating is entirely independent of the power, an excellent opportunity was presented to obtain exact data as to the heating requirements.

The heating diagrams were made from records taken at this building from December 18th to December 26th, 1901, and show:

1st. The temperature in degrees Fahr. of the outside air.

2nd. The wind velocity in miles per hour.

3rd. The approximate boiler H. P. required.

4th. The pressure referred to atmosphere in the steam and return pipes.

5th. The average coal burned per hour, plotted in six hour periods.

From these data it was found that 185 H. P. would be re-

quired to heat the building at zero Fahr.; there had been provided boilers in duplicate of 200 H. P. each.

The largest steam riser is but one and one-half inches diameter—twelve-stories high, 170 feet long, and serving 600 square feet of radiator surface.

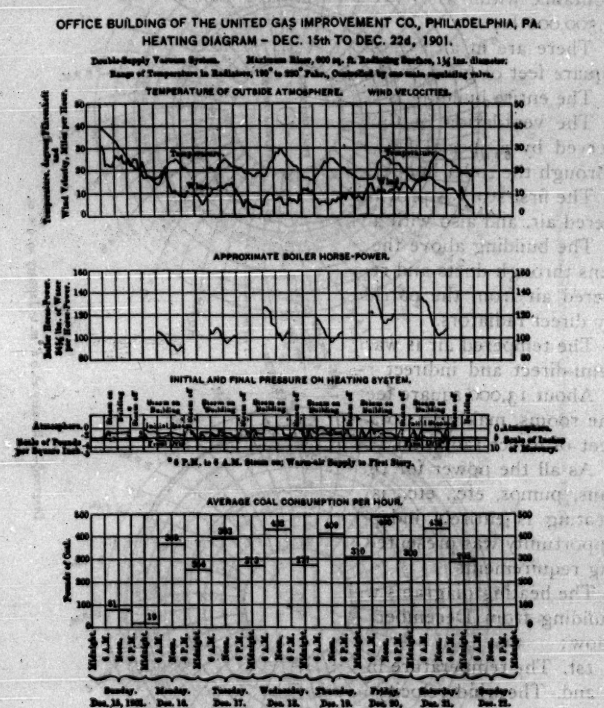

OFFICE BUILDING OF THE UNITED GAS IMPROVEMENT CO., PHILADELPHIA, PA.
HEATING DIAGRAM – DEC. 15th TO DEC. 22d, 1901.
Double-Supply Vacuum System. Maximum Riser, 600 sq. ft. Radiating Surface, 1¼ Ins. diameter.
Range of Temperature in Radiators, 120° to 220° Fahr., Controlled by one main regulating valve.
TEMPERATURE OF OUTSIDE ATMOSPHERE. WIND VELOCITIES.
APPROXIMATE BOILER HORSE-POWER.
INITIAL AND FINAL PRESSURE ON HEATING SYSTEM.
AVERAGE COAL CONSUMPTION PER HOUR.
Sunday, Dec. 15, 1901.
Monday, Dec. 16.
Tuesday, Dec. 17.
Wednesday, Dec. 18.
Thursday, Dec. 19.
Friday, Dec. 20.
Saturday, Dec. 21.
Sunday, Dec. 22.

FIG. 3.

By the operation of one automatic valve in the initial steam supply mains a range from 190° to over 230° Fahr. has been obtained to suit the varying conditions of the outside weather. This flexibility can be increased to a range of at least 60° Fahr. so that the radiating surface may be figured for the average

Diagram—January 18, 9 a. m. to January 19, 9 a. m.

Diagram — January 19, 9 a. m. to January 20, 9 a. m.

winter weather, say 30° Fahr., and when the incidental very cold snaps obtain the steam pressure in the system, and consequently the steam temperature, can be increased—saving both in first cost and operation.

To further illustrate the operation of the double supply distribution, obtained with the Webster Vacuum system, the author submits the appended diagrams, showing the pressures on the steam supply radiators and drip pipes from Friday, January 18, 1901, at 9 A. M., to Sunday, January 20, at the same hour.

On the diagrams showing the steam pressures in the supply pipes the hourly outside temperature and wind velocities have been plotted, and show how the wind velocities reduced as the outside temperature lowered. The temperature in the building was maintained at 70° during office hours, which lowered slightly during the night, after steam was shut off.

On January 18th the initial steam pressure on the supply pipes varied from 1 to 2 lbs. below the atmosphere from 9 A. M. until 7.45 P. M., when all the steam was shut off and the vacuum pump stopped.

The pressure then reduced by condensation to 6 lbs. below the atmosphere. Leakage of air into the system produced an equilibrium at 3.00 A. M., January 19th, when the pump was started.

Steam was then turned into heating system, and atmospheric pressure was maintained until 7 A. M., when it was reduced to 1 lb. below the atmosphere until 9.45 A. M., and varied from 1 lb. below to atmospheric pressure until 6.45 P. M., when steam was shut off, and the *pressure reduced by condensation to 6½ lbs. below the atmosphere.*

Leakage did not fill the system with air until after midnight. The vacuum on the drainage system produced by the pumps varied from 1 to 2½ lbs. below the atmosphere, and the difference between the initial and final from ½ to 1 lb.

In the heating system from which these diagrams were taken, the steam risers were 1½ inches in diameter, and 170 feet long; each served about 600 square feet of radiation.

The initial steam pressure on the system may readily be raised from 2 to at least 10 lbs. above the atmosphere during

the most severe conditions, producing a correspondingly higher temperature in the radiators.

To illustrate the comparative dimensions of the supply and drip pipes as used by the different systems, a diagram is exhibited. Curve No. 3 shows the diameter of the risers for the corresponding radiator surface, if they are provided with a double supply, and the system is drained by gravity, or by the Webster Vacuum System, supplied either from top or bottom.

Curve No. 4 shows the diameters of the pipes in the Webster Vacuum System supplied from both ends.

The writer has found that the size of the drip pipes noted in Curve No. 6 is sufficient for the risers on the gravity two-pipe system.

In tall buildings it is not considered good practice to make the least dimension of the riser less than 3 inches diameter, increasing toward the source of the supply; say, in a 24-story building, the riser serving 1,200 feet of radiation, the largest diameter of pipe on a one-pipe system would be not less than $3\frac{1}{2}$ inches, and with a double supply vacuum system the diameter would be less than 2 inches.

In serving the risers from both top and bottom, the building is practically divided into two buildings, one served from above, the other from below, with the advantage of equating the variable steam demands from either the upper or lower supply.

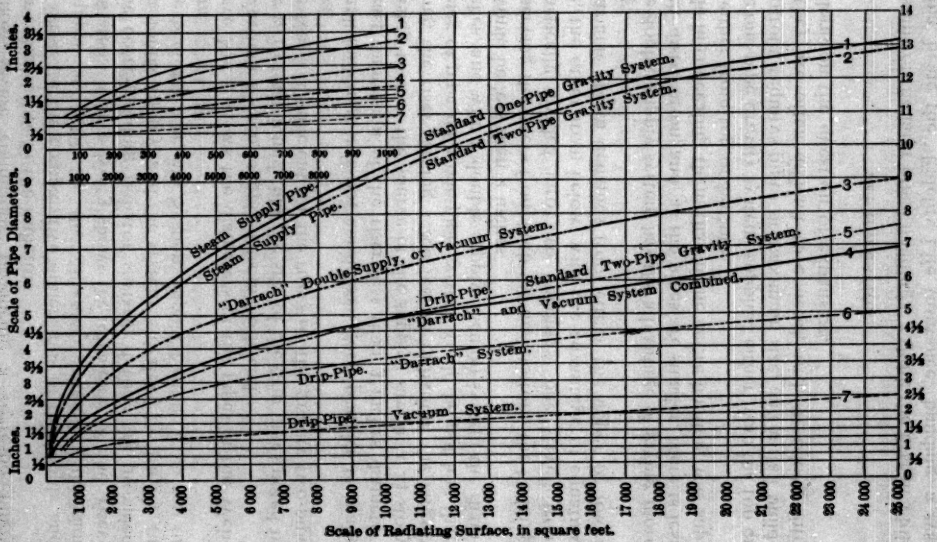
The double-supply system has the advantage of giving more equable distribution, and, as the pipes are smaller, there is less trouble in concealing them than if the entire building was supplied either from top or bottom.

The one-pipe gravity system, supplied either from the top or the bottom, requires pipes of maximum size, and in tall buildings they are often difficult to conceal, without taking into consideration the question of expansion.

REFRIGERATION.

In some of the later office buildings, I think the first in Philadelphia, being the "Fidelity Life Insurance" building, a system of refrigerated water was installed, serving individual offices for potable purposes.

COMPARATIVE DIAGRAM OF STEAM HEATING AND DRIP-PIPES.



This is accomplished by the well-known ammonia process.

Cool air is also supplied to a limited number of large offices, theatres, etc.

In the Land Title building this is accomplished by passing the air through a veil of falling water. In 1902 the author recommended, for the installation at the Gymnasium of the U. of P., substituting in the summer cool water for steam in the coils used to temper the air used for ventilation.

The transition from steam to gas as a prime mover has been described, as well as the use of electricity as a conveyor, which system, however, does not produce a usable by-product.

He is of the opinion that a better and cheaper sub-agent can be utilized.

When compressed air is used in an expansive engine the exhaust is reduced to a low temperature, depending upon the initial compression.

Thus, in giving a vehicle for *power and cold*, and we obtain, all that can be desired in addition to our old friend steam, which is the vehicle for *power and heat.*

During the winter the exhaust steam is used to heat the building and the water, etc.

During the summer the exhaust air may be used to cool the building, the water, etc., by means of the same apparatus installed for heating.

The double-supply system of distribution herein before described for steam heating is most *apropos.*

If we install in the basement only the boilers, the steam engines and air compressors and house pumps, all the other apparatus may be located in the attic.

WATER PURIFICATION.

There was installed in the Drexel Building (1887) a duplicate system of rapid sand filters, designed by M. Henry Roeske, so arranged that the sand could be sterilized with high pressure steam.

These filters were supplemented with ample storage for filtered water in the attic.

They have never been taxed, although the population in the building has been doubled, and now, after nearly twenty years

of service they are still jogging along in a comfortable and vigorous old age.

This was the state of the art and of the so-called "American system of mechanical filtration" in 1887.

Since that time many excellent forms of filters suitable for isolated plants have been put on the market, among others "The Loomis-Manning Filter," "The American Filter Co.'s" apparatus and the "Roberts" filter.

All these filters differ principally in the mechanical methods utilized in cleaning the filtering material, be it sand, animal charcoal or both; the coagulation of the organic impurities usually being induced with alum.

The utilization of the electric current for coagulation and for the aeration of the water, although first proposed before 1880, has not as yet reached much further than the experimental stage.

In his experiments the author has successfully removed all trace of stain by aniline dye, and is convinced that not only clarification, but in high degree of purity can be attained by a combination of chemical, electrical and mechanical methods, which will not be beyond the reach, either in first cost, or in expenses of operation, of all community buildings, be they office, hotel, hospital or factory.

OPERATION.

I have already tried your patience beyond the limit, but if you will permit I will speak a few words in relation to the economy of operation of the plant.

The most important is to reduce the expense of the combustible to a minimum; we should, therefore, use a minimum amount of the best quality at the lowest price.

To accomplish this result, every plant should be provided with a weighing apparatus, not only to weigh or measure all the combustible that is delivered to the building in bulk, but also all burned by each shift. The resulting ashes should also be weighed and records kept.

Contracts for combustible should be based to a standard and periodic tests made to enforce the stipulated provisions.

The boilers should be of such capacity as to be operated at the rate of maximum economy with ample reserve.

If you have a limited boiler capacity, urge your principals, in season and out of season, to enlarge it; remembering that then you can burn at minimum cost the rice sizes.

Also, in addition to anthracite, be prepared to burn any combustible—gas, alcohol or bituminous coal—for which cheap apparatus can be installed for any boiler and any setting, without in any way interfering with either the usual operation or with the smoke ordinances.

Great care should be taken that all the exhaust steam possible is utilized, and that no leaks of steam and hot water are permitted.

In this connection your particular attention is called to that insignificant but necessary steam trap—probably, when neglected, the most wasteful apparatus in the installation, located, as it generally is, both out of sight and out of mind, it wastes while you sleep. Install as few and as conspicuous as possible, and give them your individual care. Boilers and engines should be as economical of steam consumption as the invested interests will warrant, and kept in prime condition.

To this end, the operating engineer should be able to use and (in addition to the ordinary scales and the gauges required by law) be provided with indicating and recording gauges for steam, electricity and water, as well as with thermometers, manometers and indicating apparatus.

You may then only expect a minimum expense for fuel.

The next item is in the cost of lubricants. There is no doubt that many of the oil bills can be reduced to much less than half, with more intelligent care and less labor.

Improvements in apparatus for substituting lubricating grease for oil will, in the near future, reduce both the labor and the lubricant to a minimum.

Particularly urge your principals to abandon all automatic flushing apparatus in your sanitary plumbing. The chain pull or the flushometer is better, more certain and you don't have to pump so much water, even if the municipal authorities don't care how much is wasted.

CONCLUSION.

In conclusion, I would urge the intelligent, earnest, self-abnegating and courteous co-operation among the many inter-

ests and individuals to whom is intrusted the production, operation and maintenance, of that marvel of our present civilization, THE COMMUNITY BUILDING.

Philadelphia now has a world-wide reputation for loss of civic pride. Why is she called provincial? Why must she scour the wilds of some Terra del Fuego for talent to design, to construct or to manage her affairs?

Notwithstanding, it can be said, without contradiction, that the most novel scientific inventions and the most important discoveries that have benefitted mankind have been the productions of her own born citizens, fostered by the *Alma Mater* of Western Science—this institution, of world-wide fame—

THE FRANKLIN INSTITUTE.

DISCUSSION.

MR. CHAS. A. HEXAMER:—The interest of the fire insurance engineer in modern office buildings is mainly in the construction, interior fire protection, protection against fire in adjacent buildings, and housekeeping, that is to say, in the general condition of the building as to cleanliness, disposal of waste paper and rubbish. The question of construction, heating, lighting and ventilation has been clearly set forth by Mr. Darrach. As to interior protection, the insurance engineer generally recommends a standpipe supplied by an elevated tank and a fire pump, hose outlet on standpipe not less than two inches. Three gallon chemical extinguishers are required, and a forty gallon chemical extinguisher on wheels, located on each floor, is recommended. As an example of standpipe and hose system, attention is called to the arrangement in the Land Title Building, Broad and Sansom Sts. Their being no fire pump available, a 3,500 gallon pressure tank was located in the twenty-first story. This tank primarily supplied the standpipe, but as the amount of water available is small, a three and one-half inch screw connection to standpipe was provided outside of building line for the purpose of making connection by means of a hose line with the hydrant of the high pressure fire system. By this simple arrangement an efficient water supply

to the standpipe was secured for any emergency and for every story of this extra high building. The pressure tank referred to, is also connected with the sprinkler system installed for the protection of the waste paper room in the top floor, which room has been reduced to a minimum size by enclosing same with fire resisting partition. It is interesting to note that an actual fire in this room was extinguished by a single sprinkler opened by the heat of the fire.

The protection of office buildings against a possible fire in an adjacent building needs careful consideration. Wire glass windows or outside open sprinklers over the windows, if the exposure is moderate, or standard fire shutters, are recommended. As an example: In the case of the Girard Trust Building at the N. E. corner of Broad and Chestnut Sts., the the windows in the east wall exposed by the Mint Arcade have been protected by steel shutters and in addition a system of open sprinklers over each shutter has been installed. This system of open sprinklers is supplied by a steam fire pump located in the basement of the building, and in addition a three and one-half inch screw connection has been provided on the Chestnut Street front of the building, so that by means of a hose line and the hydrant on Broad Street the high pressure pipe line could be made available to supply the open sprinklers.

As to house-keeping: It is essential that the waste paper accumulating in the offices be regularly removed and not allowed to accumulate in the building. A waste paper room, of a minimum size, and enclosed by fire resisting partitions located preferably in the basement, is recommended. The waste paper room should by all means be protected by automatic sprinklers. Rags used for cleaning purposes, particularly if oil is used to rub down and polish furniture, should be carefully disposed of, and not, as was done in my own office, placed in a cupboard in immediate contact with the hot steam pipes. It should always be remembered that while a modern office building may be of fire resisting construction, as a general thing there is sufficient combustible material in any one room to cause serious damage should fire occur. How seriously a so-called fireproof office building can be damaged in a conflagration, was demonstrated at the time of the Baltimore fire.

MR. JAMES CHRISTIE:—When the so-called direct system of heating is employed, the ventilation is unsatisfactory. The indirect system, by filling the rooms with a sufficient supply of pre-heated air, is best from the hygienic point of view, but, unfortunately, the cost of heating is usually greater by the latter method. Frequently good results can be obtained from a combination of the two systems, the corridors, etc., being filled with pure air at a moderate temperature, and apartments brought to the desired higher temperature by direct radiation.

When a supply of cool, dry air can be economically obtained, the same indirect system used for winter heating can be applied to cooling in summer.

This has been done to some extent in connection with a refrigerating system, and permits of windows being kept closed in summer, thus excluding a dusty or smoky atmosphere, a most desirable object in some locations. At the new works of the American Bridge Company, at Ambridge, Pa., there is an ample supply of cold water, running 55 to 60° Fahr. in the hottest months.

The water supply of the office, in the summer months, can be passed through the same coils in which steam is used for heating in winter, the same fans that push warmed air in winter discharged cooled air in the hot months, thus, in addition to well-aired offices, it is practicable to reduce the temperature from 5 to 10° below that otherwise existant.

DEEPOSITING COPPER ON ALUMINUM.

Copper has been successfully deposited upon aluminum by the use of an anode of pure copper and an electrolyte of water, with a few drops of sulphuric acid in it. After the current had been in action for some time copper sulphate was formed, and from this the copper was deposited. After thirty minutes the plate was taken out and well washed in water, then in a solution of hydrochloric acid, then in sodium hydroxide, and again in water. This operation was repeated several times, the final result being an even deposition of copper all over the plate. Further experiments included the deposit of antimony upon the coppered aluminum plate. Lumps of trisulphide of antimony were placed in a porous pot with a carbon anode, and the cell filled with the electrolyte, which in this case was a concentrated solution of sodium sulphite. On the coppered aluminum cathode the antimony adheres firmly, the current density being 0.0013 amperes per square inch, with a pressure of from 1 to 1.5 volts. —*Iron Age.*

CARBONIC ACID AS A CAUSE OF RUST.

In view of the important place given to preservative coatings in the programmes of engineering associations and the divergent views on the cause and prevention of rust, interest attaches to the data presented by Gerald Moody of the Central Technical College, at a recent meeting of the Chemical Society in London. The accepted theory has been that the presence of oxygen and moisture would always cause rust, and the view of some chemists that carbonic acid played an important part in the reaction has been considered disproved by experiments carried on by Dunstan, Jowett and Goulding.

Mr. Moody, as reported by the London *Engineer*, held that minute traces of carbonic acid are sufficient to set up atmospheric corrosion, and he entered upon a series of experiments to justify his opinion. In these experiments extraordinary precautions were taken to exclude the minutest traces of carbonic acid. His plan was to keeo a sample of highly polished iron in a few drops of distilled water for prolonged periods and to draw over it a continuous stream of air freed from carbonic acid by passage over caustic potash and soda lime. In some instances three weeks were expended in purging the apparatus of carbonic acid alone before the water was allowed to reach the iron, and for six weeks the pure air passed over the sample. At the end of this time the iron was as bright as when the experiment began. But, on the other hand, when air containing the normal quantity of carbonic acid was drawn over the sample, in six hours the bright surface was tarnished, and in seventy-two hours, during which time about sixteen litres of air passed over it, "the whole surface of the metal was corroded and a considerable quantity of red rust collected." The question presented by these experiments to the manufacturer of preservative coatings is how to exclude or neutralize the action of the carbonic acid carried by the atmosphere or by moisture.

Two correspondents of the *Engineer* comment on the above to the effect that there must be moisture to cause rust. One says that the experiment of the late Prof. Crace Calvert, in 1869 to 1871, showed that with dry carbonic acid there was no oxidation, and that the most rapid corrosion took place when the iron was exposed to damp "oxygen and carbonic acid." The other correspondent says that in all cases of rust water as well as carbonic acid and oxygen must be present; that no oxidation can take place without water, though it has not been ascertained how much moisture must be present or the precise part it plays.

HEATING VALUE OF COAL AND CRUDE OIL.

Tests have been made in California to determine the relative heating value of crude oil and local coal. One net ton of coal was found to be equal to 718 pounds of oil. As this oil weighs 7.6 pounds per gallon, and one barrel holds 42 gallons, the above quantity is expressed as 2¼ barrels. For locomotive purposes, where a better grade of coal is used, the requirement of oil to equal 2000 pounds of coal is 1037 pounds, or 3¼ barrels.

ONE LESSON OF THE EARTHQUAKE.

If argument were needed to show the advisability of an investigation of structural materials it is more than supplied by the recent earthquake in California.

What buildings best stood the shock is a question of very great practical interest. Why they endured while others fell is food for thought to builders all over the country.

In this connection it is interesting to note that the Appraisers Building in San Francisco, where the United States Geological Survey maintains a local office, is one of the few business structures in that city which was uninjured either by shock or by flame. Mr. Charles G. Yale, special agent of the Survey, reports that a little plaster has fallen but that the building is probably the only one in the city that shows not a single crack in its brick walls. This may be due to the fact that the foundation consists of a six-foot bed of solid cement placed upon thousands of piles, and that the bricks are put together with cement instead of mortar. The walls are thicker below the sidewalks than above them. When the building moves, it moves as a monolith, and while the vibration is considerable, no damage has been done except to the plaster.

That the Geological Survey might with profit to the country undertake the investigation of structural materials is attested by the numerous requests which it receives for information on the subject. Twice during the past year the Survey was visited by a body of engineers who represented large industrial developments in a number of different States. The Survey was unable to supply the information which they desired concerning the strength and endurance of materials to be used in a variety of building and construction work. This one fact shows how desirable it is that the investigations now under way by the Survey be enlarged.

These investigations have thus far had to do mainly with the testing of cements and concretes. It is felt that the work should be continued and amplified.

LARGEST PAPER-MAKING MACHINE.

Some idea of the dimensions of the largest paper-making machine ever constructed in the United Kingdom may be had from the fact that it fills a shed 185 feet long. It has great width, due to the fact that the Swedish Paper Mill Company, for whom it was built, intends to use it for the production of two 75-inch sheets of paper, a total width of 150 inches, or 12½ feet. The paper is to be run through the machine at the high speed of 500 feet per minute, which calls for very heavy and accurate driving gear and large rolls. To provide paper of a superior finish a stack of calendar rolls is fitted, weighing seventy tons, the lowest one alone accounting for nearly fifteen tons. The entire machine weighs 550 tons, and is driven by a 200 horse-power steam engine. The machine was built in Edinburgh, and conveyed to Sweden in a special steamer chartered for the purpose.

CHILEAN NITRATE DEPOSITS.

According to recent publications by Semper and Michels (Berlin, Ernst, 1904), the various theories hitherto proposed to explain the formation of the Chilean saltpeter deposits (microbes, varech, guanos, etc.) must give way to those formulated by the *saliteros*, or Chilean miners, who ascribe the formation of saltpeter to atmospheric electricity. There is a remarkable amount of mist surcharged with electricity in the Pampas, where the saltpeter is mined, so much so that telephones are deranged. Apparently the oxonized air disengages nitrate of ammonia, which combines with rock salt to form saltpeter. But as the region is rich in guanos and other organic deposits, says the *Mining Journal*, there might be reason to blend this theory with that of Ochsenius.—*Eng. and Min. Jour.*

BEHAVIOR OF INCANDESCENT MANTLES.

In using incandescent mantles for gas lighting it is usually found that illumination increases for a short period, after which a slow but steady fall sets in. The initial rise is credited to a gradual shaping of the mantle to the flame. The subsequent fall is attributed to two causes. One is that dust particles of silica are carried by the draft against the mantle, where they form, with the oxides, infusible silicates of low emissive power. The other, and more potent cause, is the gradual volatilization of the ceria, to which the incandescence is due. It is also found that the hygroscopic state of the atmosphere has a small but measurable influence on the luminosity of the mantle.—*Iron Age.*

MEASURING FLOW OF AN ARTESIAN WELL.

Under conditions where a weir could not be built, a novel way of measuring the flow of an artesian well was devised. Forty feet of ten-inch pipe was screwed into a ninety-degree elbow on the pipe where it came out of the ground, and a hand force pump attached to a small hole tapped into this pipe. The force pump drew a red aniline liquid from a pail and injected it into the stream, where it was carried along with the water and at the same rate. By means of a stop watch and the known carrying capacity of the pipe the flow of the well was easily determined.—*Iron Age.*

Book Notices.

PUBLICATION RECEIVED.

U. S. War Department. Annual reports for the fiscal year ended June 30, 1905. 4 vols., maps, plates, 8vo. Washington, Government Printing Office. 1905.

Argument on the Brooklyn Bridge Problem. Submitted to the Hon. James W. Stevenson, Commissioner of Bridges, by Max E. Schmidt, Chief Engineer and General Manager, Continuous Transit Securities Company. 12 pages, maps, 8vo. New York, April, 1906.

Iowa State College Engineering Experiment Station, Bulletin No. 3, vol. 3. Notes on Power Generation in Iowa. 24 pages, illustrations, 8vo. Ames, Iowa, December, 1905.

Application of Thermit. Foundry practice: welding. Goldsmidt Thermit Co., New York. (Pamphlet.)

Hints and Helps for Young Gardeners. A treatise designed for those young in experience as well as youthful gardeners, by H. D. Hemenway, Director, School of Horticulture, Hartford, Conn. 59 pages, illustrations, and plates, 8vo. Hartford, published by the author, 1906. Single copies, 35 cents; per hundred, twenty dollars.

Electric Hauling of Boats. Notice of the tests relating to proportional adhesion tractors by Leon Gerard. Taken from the Bulletin de la Societe Belge d'Electriciens, vol. 22, 1905. 16 pages, illustrations, plate, 8vo. Brussels, 1905.

Permanent International Association of Navigation Congresses. ×Congress, Mr. lan, 1905. An economical and technical study of the mechanical traction of boats on rivers, canals and lakes. Report by St. John Clark and Leon Girard. 40 pages, illustrations, 8vo. Brussels, Printing Office of the Public Works, 1905.

Investigation of the effect of heat upon the crushing strength and elestic properties of concrete by Ira H. Woolson. Authorized print from the copyrighted Proceedings of the American Society for Testing Materials, Philadelphia, Pa., volume 5, 1905. 28 pages, illustrations, 8vo.

Ontario Bureau of Mines. Report for 1905, vol. 14, 2 parts; part 1, 374 pages, illustrations, maps; part 2, devoted solely to the Cobalt-nickel Arsenides and Silver Deposits of Temiskaming, by Willet G. Miller. 66 pages, illustrations, maps, 8vo. Toronto, King's Printer, 1905.

Annual Report of the Chief of the Bureau of Steam Engineering, Navy Department, 1906. 60 pages, 8vo. Washington, Government Printing office, 1905.

Transactions of the American Electrochemical Society, vol. 8. Eighth general meeting, Bethlehem, Pa., September 18, 19, 20, 1905. 299 pages, illustrations, portraits, 8vo. Philadelphia, published by the Society, 1905.

Le Slipmètre. Communication faite par l'Ing. Angelo Bianchi avec presèntation de l'appareil en fonction seance du 10 Mai, 1904, de la Section de Milan de l'Associazione Elettrotecnica Italiana. Extrait des actes de l'Associazione Elettrotecnica Italiana. 8 pages, illustrations, 8vo. Milan, Antonio Cordina, 1905.

Public Health, Michigan. Issued for the general dissemination of sanitary knowledge. Published quarterly by the State Department of Health, Lansing, Michigan. Vol. 1, No. 1, January—March, 1906. 45 pages, illustrations, 8vo.